Product Engineering

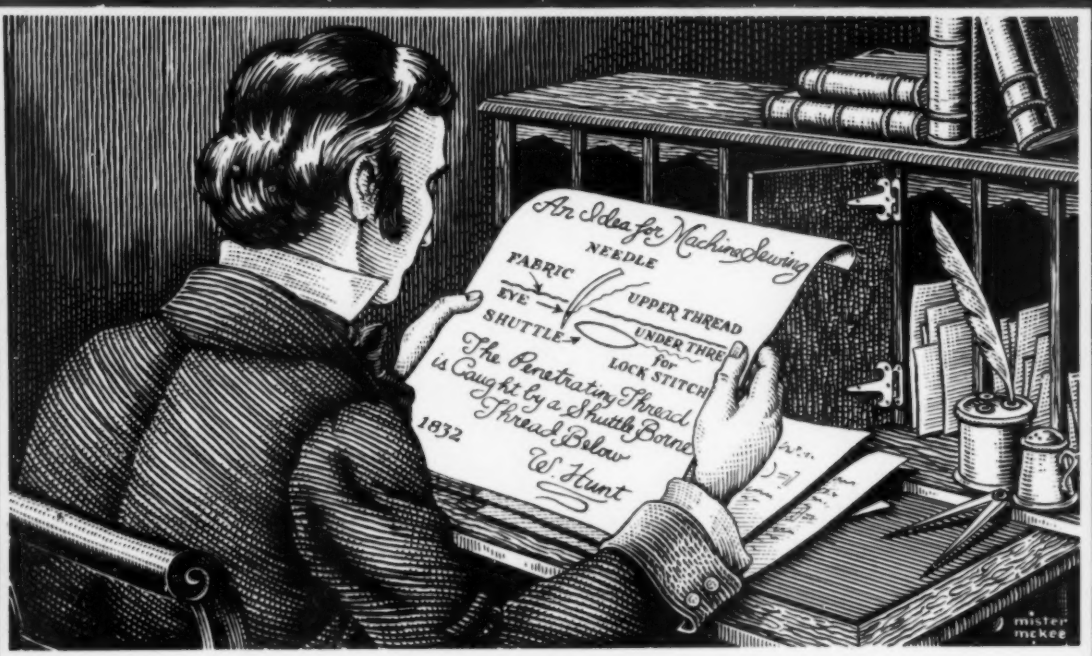
SEPTEMBER 1953

A McGRAW-HILL PUBLICATION

FIVE DOLLARS A YEAR

Shell Molding of Stainless Steel
Servo Systems for Mathematical Operations
V-Belt Drive Selection
Pressure Surges in Hydraulic Circuits
Using Models in Design
Check Lists for Springs

TOUGH PROBLEMS AND THEIR GREAT SOLUTIONS



Two Million Dollars for a Needle

Sewing is probably as old as mankind, but not until the year 1832 did the hole move to the point of the needle, so that machine sewing became possible. Walter Hunt of New York City had this great idea, combining with it the shuttle-carried lock-stitching thread on the underside of the fabric.

Elias Howe usually gets credit for inventing the sewing machine, but actually he worked out the idea twelve years after Hunt. Howe, you see, had the good sense to patent the idea. It brought him over two million dollars.

It's great to have an idea. It's much more wonderful to make it work. That's where we come in.

Often difficult and unusual problems are involved in operating mechanisms that depend on *pliable parts*. These must be *composed* and *designed* for continuous dependable service under a wide variety of environment and operating conditions, often in the presence of deteriorative materials or conditions.

For such critical parts, perhaps the most versatile and reliable material ever developed is SIRVENE. This is an oil-resistant elastomer (loosely called synthetic rubber) *compounded in formula* as will best meet the specific need.

SIRVENE engineers are constantly working on pliable part problems, in scores of fields. They are constantly developing new SIRVENE compounds. And when design and compositions are determined, C/R quantity production takes over, operating at laboratory-quality level.

Let SIRVENE engineers work with you from the inception of your idea for a new product. They can short-cut your work, protect you in advance against disappointment.

"Engineering with Sirvene" will be sent with our compliments if you request it. It belongs in your files.

Sirvene products include diaphragms, boots, gaskets, oil seals, washers, packings and similar molded parts.

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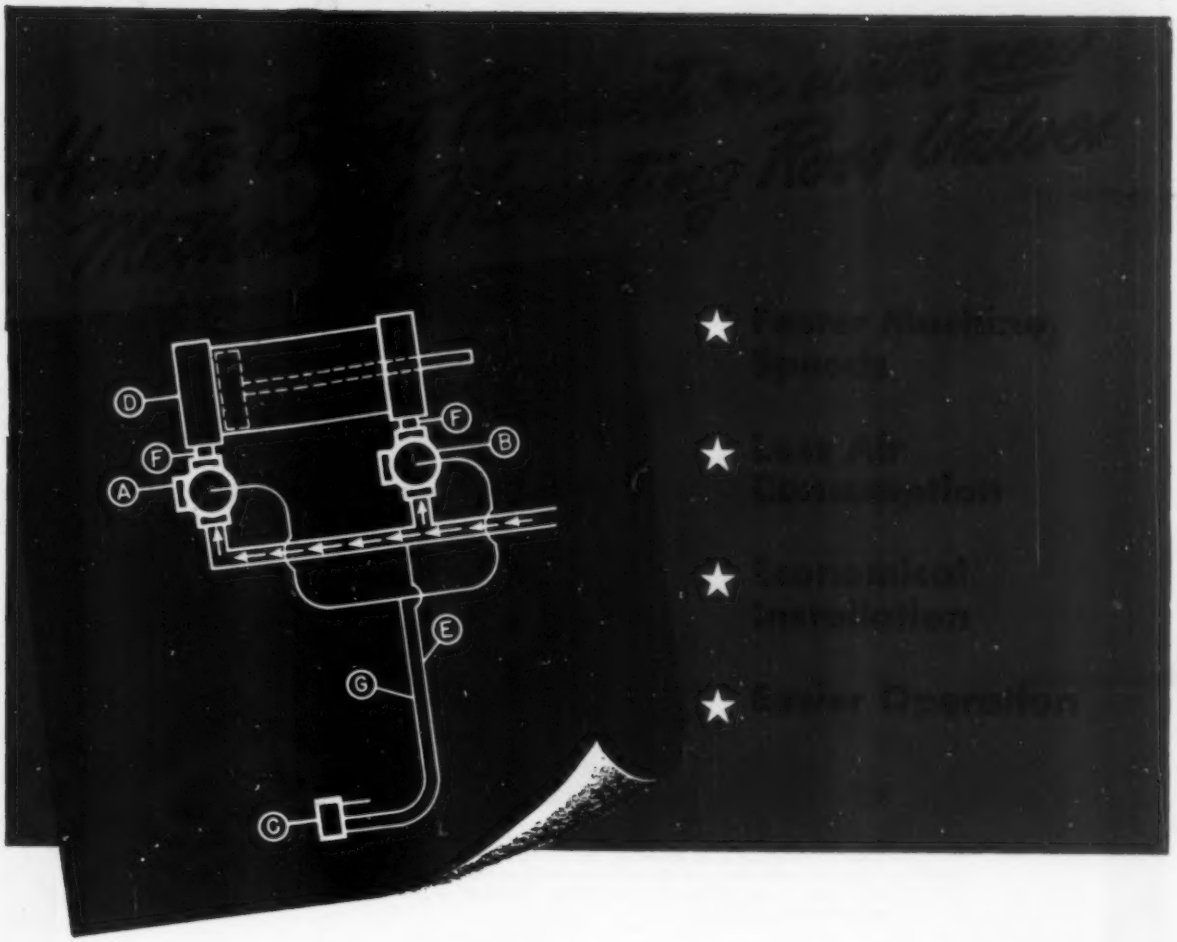

Close-coupling of valve to cylinder! That's the story behind the remarkable success of the *new Ross In-Line Master Valve.*

Users claim several important advantages. By placing the master valves (A & B) at the cylinder (D), air supply and exhaust are speeded up appreciably. This in turn permits faster movement of the cylinder piston and materially increases production.

At the same time, the close coupling means that two lengths of large diameter piping between valve and cylinder—pipes continually filled and exhausted with non-productive air—are replaced by two short connecting pipes (F). The resultant saving in air with every movement of the piston considerably reduces operating costs.

Operation is by a small, conveniently located 3-way pilot valve (C). It is supplied through tubing (E) and connected to the master valves by tubing (G). It may be mechanically, manually or electrically controlled. Hand or foot operation is greatly facilitated by the use of the smaller, more easily actuated pilot model.

The complete story of possible advantages in *your* production will be gladly furnished without obligation. Ask for Bulletin No. 302.

Ross makes valves only — hundreds of types and sizes. Take advantage of the experience gained in over a quarter century of concentration on control and application of air power!

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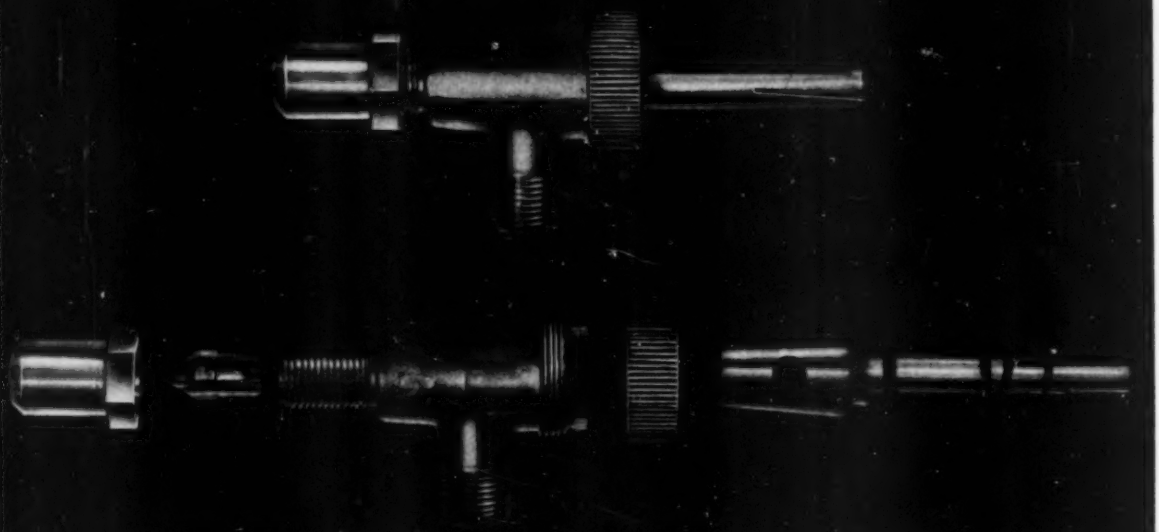
LINCOLN FINDS

Brass is Best



Kitchen range burner valve by Lincoln Brass Works, Inc., Detroit 16, Mich. Two different brasses are used in this valve, which is entirely of brass except for the washer and spring. Lincoln also makes valves for heaters and furnaces; flow, drain and shut-off valves for gasoline lines; shut-off valves for agricultural sprayers, and a wide variety of tube and pipe fittings, all entirely or chiefly of free-cutting brass rod and free-machining brass forgings.

Mr. D. E. DuPerow, Vice-President of Lincoln Brass Works, Inc., recently said: "Thirty-six years of brass use by Lincoln and complete acceptance by the trade is the best reason I can think of for brass superiority. If there had been any material better for our purpose, less expensive to fabricate, and more desirable to our customers, we would be using it now."

Brass has many desirable characteristics. Here are five of them that are important in Lincoln valves and fittings: 1, corrosion resistance, which means no plating is required. 2, high speed precision machining for high output, lower costs. 3, sound, non-porous structure of rod and forgings. 4, smooth performance; brass holds lubricants. 5, customer satisfaction; gas range burner valves pass the cycling test of being raised to 425°F. and back to room temperature a minimum of 10,000 times without seizure, loss of free operation, or leakage.

There are many other items besides valves that can profitably make use of the fine qualities of Revere Brass. The Revere Technical Advisory Service will gladly cooperate with manufacturers on the selection of the correct brass and its fabrication. Just call the nearest Revere Sales Office; see your telephone directory. Or write direct.

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Product Engineering

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THIS MONTH'S COVER

Automatic testing machine for hydraulic proof testing of flexible hose at the Jackson, Michigan plant of Aeroquip Corporation. Proof pressures up to 9,000 psi—one-half the burst pressure and 4,000 psi above working pressure for a ¼ in. ID hose—can be applied by the machine, which was designed and built by the engineering department of Aeroquip. All hose is checked at proof pressure before shipment.

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for Communication, Audio and Other Electronic Applications

This new Mallory Jack effectively seals out water and moisture . . . lets your customers keep the dependable performance they bought, even when your equipment is operated out in the open . . . in all kinds of weather.

You can see how it is done in the cross section. A Neoprene "O" ring seal is tightly compressed around the shoulder of the bushing and against the inside portion of the panel board. Water can't possibly reach the jack opening and penetrate through to the inside of the chassis.

What's more, it is impossible to twist the jack and break the seal after it is mounted on the panel. A "Single D" flatted bushing on the jack fits a corresponding "Single D" hole in the panel.

Exhaustive testing has shown that the new Mallory Jack will withstand a 6 foot head of water for 24 hours.

Interested? Then let us send you a new Technical Bulletin that is just off the press. It contains complete data and is yours for the asking.

Available Types:

WS-1A—a two-circuit jack with terminals for one circuit and ground.

WS-A2B—a three-circuit jack with terminals for two circuits and ground.

Both types conform to Specification JAN-J-641, Amendment No. 1.

Other Characteristics:

Contact Resistance: less than .02 ohms before and after life test.

Insulation Resistance: 100 megohms (before humidity cycle).

Dielectric Strength: 500 volts RMS (minimum).

Minimum Life Expectancy: 5,000 insertions and withdrawals without appreciable change in spring characteristics.

Expect more . . .
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Highlights

When requesting further information from companies and organizations mentioned in the items below, confusion can be avoided by referring to the issue of Product Engineering in which items appear.

NONMETALLIC MATERIALS

. . . . A rubber film that combines the properties of plastics and synthetic rubbers and that can be electronically sealed to itself is a development of B. F. Goodrich, Akron, Ohio. Called Vulcafilm, the material permits the assembly of shapes or vessels of any size with fused, homogeneous seams. The seams are stronger than the material itself and cementing or taping is not required. The compound may be varied to obtain resistance to oil, gasoline, sunlight, heat, cold, abrasion and acids. Applications claimed are oil tank diaphragms, tank liners and inflatable pillows to solidify freight cargo and prevent damage.

SPECIAL COATING . . .

. . . . An anti-weld and anti-seize thread coating for use by manufacturers of jet engines, gas and steam turbines, diesel engines and operators of stationary or mobile units has been developed by Surveys, Inc., Trenton, N. J. The coating is claimed to withstand temperatures to 1,500 F. It prevents frozen threaded assemblies and will not suffer mechanical or chemical decomposition under normal operating conditions.

SILICONE RESIN . . .

. . . . A single silicone resin has been developed that can be used for a variety of insulating applications. G. E. reports the resin can be used for coating glass cloth for power cables and class *H* insulation, providing a tough bond for flexible mica tapes and coil wrappers, treating glass sleeving and impregnating asbestos for layer insulation. Tests indicate that the resin has no significant change in dielectric strength after exposure to 250 C for 30 days nor after being bent over a ⅛ in. mandrel at —30 C. A change in cure alters the resin for high temperature insulation or low temperature flexibility depending upon end use.

PLASTIC PIPING . . .

. . . . A test installation of reinforced plastic piping, in service for 20 months, has been found to resist shock and salt water corrosion as found on ship board installations. The U. S. Navy test reports the pipe carried salt water at 90 psi pressure without ill effect. Steel pipe under similar conditions have failed. Present investigations are to find a suitable pipe joining technique for shipboard installation and acceptable plastic fittings that are competitively priced. The piping did not prove entirely satisfactory when installed in a constant air temperature of 140 Fahrenheit. This installation was in the boiler room of the ship used for the test.

NEW SILICONE FOAMS . . .

. . . . Two of the new foams can be expanded to form uniform, unicellular structures weighing 8 to 24 lb/cu ft. Dow-Corning Co., Midland, Mich., expects that they may be the answer for lightweight, nonflammable material that will retain its compressive strength at high temperatures. They can be foamed in place, a major advantage over other types. Silicone foams have been exposed to temperatures of 700 F for over 20 hours with little structural or dimensional change.

CERAMIC INVESTIGATION . . .

. . . . Cermets, combinations of ceramics and metals, are considered likely materials for construction of reactors according to the Oak Ridge National Laboratory. But investigation of cermets will be only part of the research program. Other important work will be done on oxide, boride and nitric ceramics as structural materials, on techniques for applying ceramic coatings to materials used in reactors, and on the evaluation of radiation damage to ceramics.

METALLIC MATERIALS

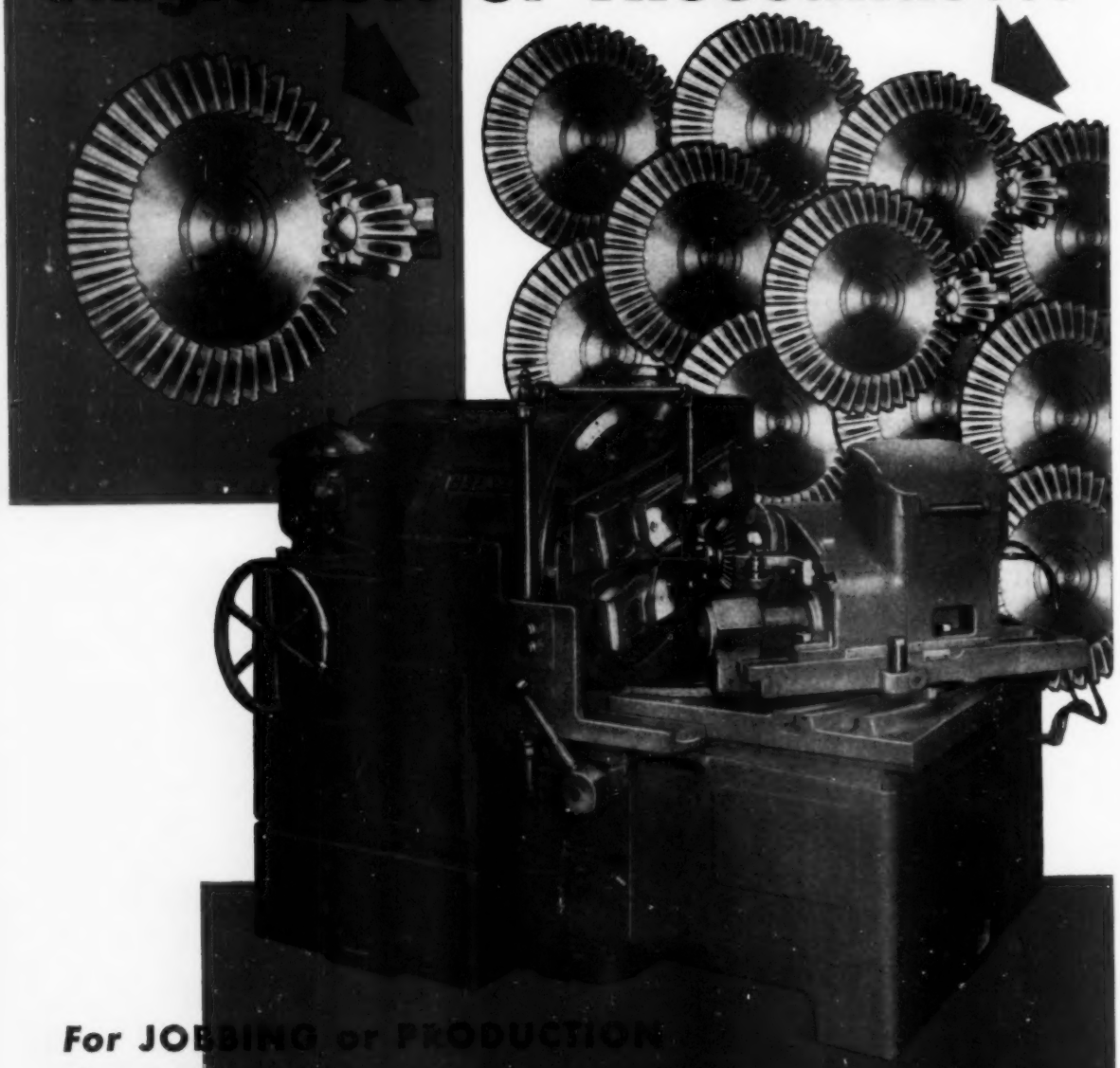
. . . . New magnesium alloys, such as FS1-H sheet and 2K60A extrusions, are considered by the Wright Air Development Center to be quite suitable for primary aircraft structures. An example of magnesium's primary use are the wings of the F-80 jet fighter which are made from a thick skin magnesium alloy assembly. Experimental wings under test for over 1,000 hr show good results except for paint adherence at high speed. Approximately 15,670 lb of magnesium are used in the B-36 bomber. Main applications are wheel castings, power plants and air frames.

TITANIUM CREEP PROPERTIES . . .

. . . . Reexamination of the creep properties of titanium by the Battelle Memorial Institute, Columbus, Ohio,

(continued on page 7)

Single Lots or Thousands...



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indicates that the commercially pure metal is unique among metals. At stresses near the room temperature yield strength, marked creep is observed but this creep is absent at stresses near the elevated temperature yield strength of 400-600 F according to the testers.

WELDING FLUX . . .

. . . . Aluminum welding flux that is claimed to reduce oxides immediately upon application and continues throughout the heating cycle has been developed by Solar Aircraft Co., San Diego, Calif. The flux is further claimed to be easily removed after welding, does not produce corrosive pitting of the parent metal and permits the use of the hotter flame of oxacetylene without fear of overheating.

BORON COATING . . .

. . . . Borides that protect against oxidation up to 2,400 F have a future as coating materials. Battelle Memorial Institute states that borides of zirconium, vanadium, tungsten and silicon can be formed to give a wide range of chemical, wear and heat resisting properties. Metallic and nonmetallic components can be coated and will be exceptionally hard because the boron can be formed in place.

BERYLLIUM RESEARCH . . .

. . . . To increase the oxide yield of beryl ore, improving techniques for manufactured beryllium alloys and the development of alloys of low beryllium content are a few of the research projects being carried on by Beryllium Corp. Other investigations on the program are new materials, such as ferroberyllium as an additive to certain steels, and alloys containing no beryllium but having some properties akin to beryllium alloy systems for future use.

COMPONENTS

. . . . A gun that will take samples during manufacture from thin sheets of material, such as paper products, plastics, textiles and metals that are moving at high speeds over rollers, is a development of the Research Laboratories of Australian Papers Mfg. Ltd., Melbourne, Australia. The gun discharges a sample cutting device through the material. The high velocity of the cutter requires no supporting back to the material; even the inertia of thin paper being sufficient to result in a clean circular sample. A circular cutter is used, as it causes the least stress concentrations that could result in sheet breakage during subsequent processing of the thin sheet materials.

URANIUM ROLLING MONITOR . . .

. . . . Radiation detection devices are being used to monitor critical temperatures during uranium rolling operations. Minneapolis-Honeywell Regulator Co., reports the robot system to be 10 times faster and 2 to 5 times more accurate than previous systems. The detection devices relay the temperature or heat of an ingot to a series of electronic recording instruments. Thus, temperature information at several points on the production line is gathered and permits a single operator to make necessary adjustments for temperature in about one to two seconds.

QUARTZ CRYSTAL . . .

. . . . An oscillating quartz crystal of minimum dimension and weight which, like other circuit elements such as resistors and capacitors, can be soldered into a circuit is a development of Telefunken, Germany. The unit consists of a ceramic pot and lid, soldering wire as R. F. leads, a quartz disk between two electrodes and a compression spring. The unit is sealed by soldering the joint between pot and lid.

AUTOMATIC CLUTCH . . .

. . . . For industrial machinery this clutch applies power from a prime mover to its load and prevents overloading of the machine beyond its capacity. The designers, Automatic Clutch Corp., Boston, Mass., report that the unit is especially adaptable for extractors, punch presses and hammer mills and that the clutch can eliminate costly starting devices. If the machinery becomes jammed or its power overtaxed, the clutch will slip until the cause is removed.

ONE WAY SWITCH . . .

. . . . For use in telephone switching systems and many types of computers is a tiny one-way switch developed by the Bell Telephone Labbratories. The unit is described as a silicon alloy junction diode and serves as the electronic equivalent of a one-way switch. The switch is claimed to operate thousands of times faster than its mechanical counterpart.

HEAT TREAT CONTROL . . .

. . . . More accurate control in the production of martempering and austempering operations has been suggested by use of an apparatus based on the volume change that takes place in the transformation of austenite. The apparatus, known as the Schaaber Dilatometer, is a German development being studied

(continued on page 9)

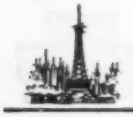
120 YEARS OF KNOW-HOW

from all over the world flows into your plant from PARKER

Parker Rust Proof Company, U.S. **38** years

Metallgesellschaft, A. G., Germany **26** years

The Pyrene Company, England **28** years



Societe Continentale Parker, France **28** years

120 years

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BONDERITE corrosion resistant paint base

BONDERITE and BONDERLUBE aids in cold forming of metals

PARCO COMPOUND rust resistant

PARCO LUBRITE wear resistant for friction surfaces

by Ajax Electric Co., Inc. The unit offers accurate and quick determination of the transformation time for austempering and the martempering time cycles wihtout reference to a TTT diagram.

PROCESSES

. . . . Further research and development work is being undertaken to improve a corrosion prevention process developed during the last war. Rutgers University and the Navy are investigating the properties, structure and functions of the substance to improve and extend its application. Most serious limitations are that it must be applied within 8 hr after preparation and its lack of effect on the light metal alloys. Among its chief attributes are its adhesiveness, strong resistance to salt water, and long life. Mixture is composed of phosphoric acid, a resin and an inhibitive pigment.

EXTRUSION LINER . . .

. . . . Various defects arising in extruded sections made from aluminum alloys because of friction between the side of the billet and the wall of the container can be eliminated. British patent No. 689,-051 recommends the use of a metal liner made from a material of lower mechanical strength and substantially higher plasticity than the billet. The liner acts as a lubricating layer and forms a coating bonded to the outer surface of the extruded section. Suitable liner materials are pure Al, Al-1 percent Zn alloy, pure Mg, and Mg—1.5 percent Mn alloy.

PLASTIC SHEET PROCESS . . .

. . . . A new method of making a light, strong and rigid sheet of plastic material in a continuous process was recently demonstrated by the Campco Div. of Chicago Molded Products Corp. The sheet is made by forcing a mixture of polystyrene and rubber through a heated dye. As the process is continuous, sheets of any length can be manufactured ranging in width from 26 to 58 in. and in thicknesses from 0.005 to 0.125 in. Color possibilities are unlimited.

STEEL POLISH . . .

. . . . A room temperature chemical steel polish that is claimed to produce a brilliant luster on most steel parts by simple chemical immersion is a development of MacDermid, Inc., Waterbury, Conn. A one min. immersion is said to produce a luster equivalent to a 30 min. deposit of bright nickel. The process is also claimed to reduce surface roughness and deburr sharp edges. It can be used to polish steel dies.

COLD FORMING AND WELDING . . .

. . . . High speed tube mills for converting non-ferrous strip by cold forming and welding into tubing has been developed by the Yoder Co., Cleveland, Ohio. The induction welding is done at speeds ranging from 40 to 120 fpm depending on the metal, gage and diameter. The weld is made by a high frequency current introduced through a short inductor coil. The current travels around the surface of the tube and flows along the converging edges of the unwelded tube to a point of convergence near the rollers which press the seam edges together. Aluminum tube can be commercially produced to wall thicknesses of 0.025 inch. Metals that can be used are aluminum alloys, certain magnesium alloys, a wide range of brasses and copper, stainless and the lighter gages of carbon steels.

TESTING

. . . . Quick, accurate analyses of particle size distribution can be made with a new research instrument developed by Sharples Corp., Bridgeport, Conn. The unit permits fast quality control checks on pigments, metal powders, abrasives, ceramics and other powdered materials. One operator can analyze billions of particles in 15 min. with a probable error of ± 3 percent. A continuous record of the weight of powder settled on a balance is plotted against time to arrive at the particle size distribution curve.

MINIATURE REACTOR . . .

. . . . A low-power nuclear reactor has been placed in operation at the Knoll Atomic Power Laboratory, Schenectady. The reactor is a source of nuetrons that can be used in many fields of fundamental research. To detect element absorbtion, for example, the reactor is first operated at a uniform level. The test sample is then lowered into the reactor and nuetron absorbtion by the sample will slow down the reactor. Control rods are withdrawn to restore the original operating level and the difference in rod length is the absorbtion of nuetrons by the sample.

STEEL STUDIES . . .

. . . . To test new steels for use with enamel finishes and the application of ceramic jackets on steel parts to increase resistance to high temperatures are two reasons for the new U. S. Steel Corp. research laboratory. U. S. S. says it intends to test many new and standard steels at the high level temperatures required to bake on porcelain enamel coatings. These tests will determine which steels are best for use in porcelain-enameled products and what heat treatment gives the best results over extended periods.

SKINNER ELECTRIC VALVE DIV.
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☐ Send full information on valves for _____

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Company _____
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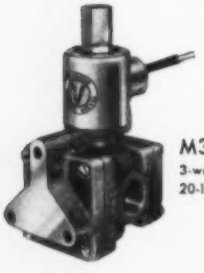
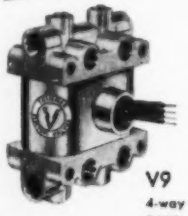


M3
3-way
20-150 p.s.i.

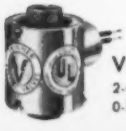


V9
4-way
0-150 p.s.i.

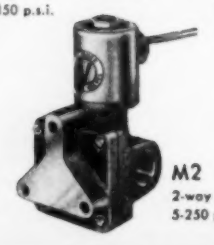
V61
2-way
0-300 p.s.i.

V5-2
2-way
0-1000 p.s.i.

X5
Same as V5 valves (except explosion proof)
0-300 p.s.i.



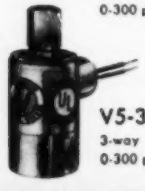
V2
2-way
0-200 p.s.i.



M2
2-way
5-250 p.s.i.

V10
3-way
0-1000 p.s.i.

V50
2-way
0-3000 p.s.i.



V5-3
3-way
0-300 p.s.i.

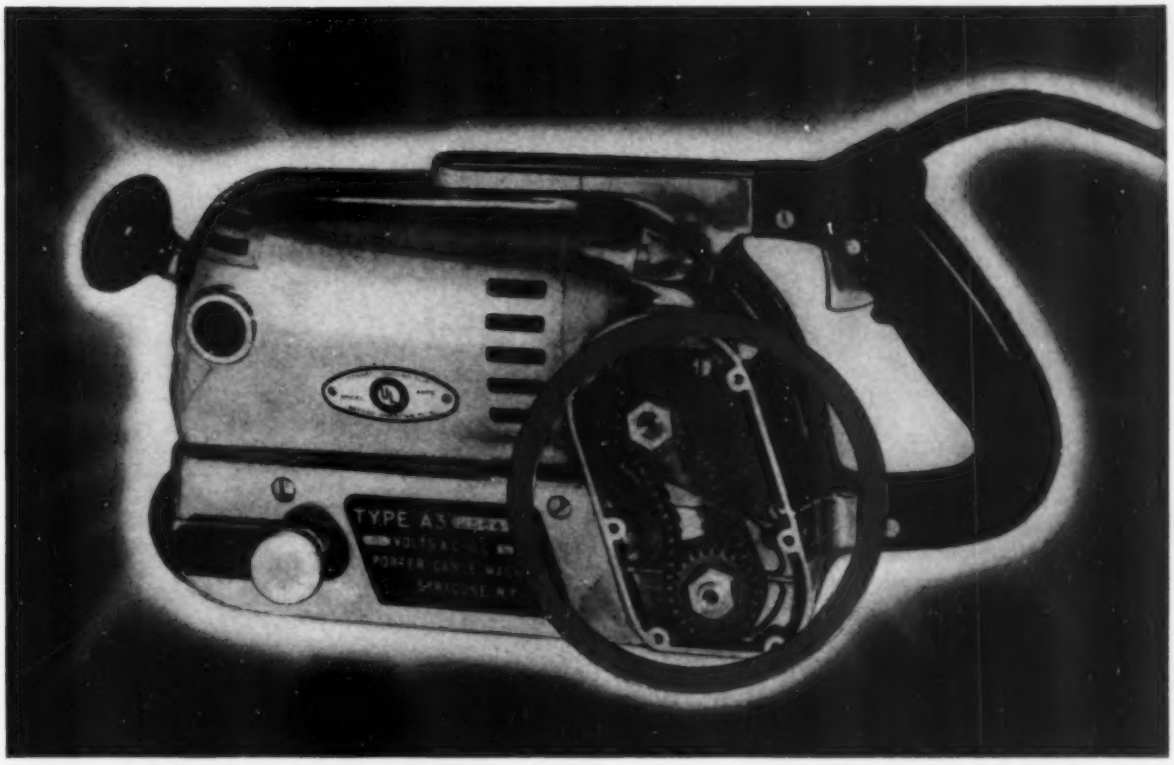
SKINNER ELECTRIC VALVES®

SKINNER SOLENOID VALVES

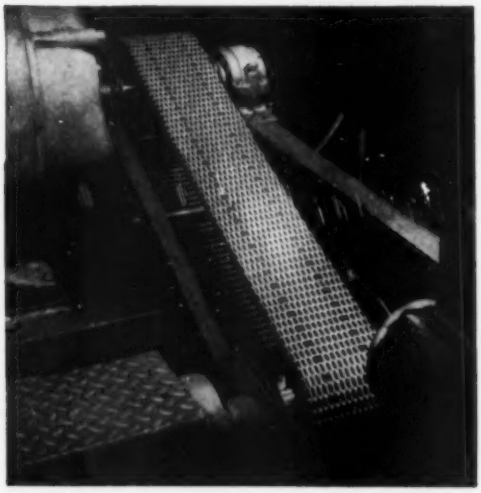
SKINNER ELECTRIC VALVE DIV., The Skinner Chuck Company, 114 Edgewood Ave., New Britain, Connecticut

To maintain high efficiency at high speeds

design with LINK-BELT Silent Chain



Portable belt sander is driven with Link-Belt ⅜-in. pitch silent chain. This compact, high-speed chain operates over small wheels, utilizes a spring shoe type tightening mechanism. Its exclusive link and tooth form eliminates chordal disturbance.



Printing "class" magazines calls for precise register of exacting color illustrations at high speeds. As on the majority of the country's high-production presses, Link-Belt Silent Chain provides the drive for this 5-color press that turns out 15,000 impressions per hour.

From fractional to thousands of hp --- your assurance of positive, dependable transmission

SMOOTH, quiet operation is one big reason why so many top designers use so much Silverstreak Silent Chain. Another is the *sustained* efficiency of these positive, no-slip drives—better than 98% throughout their long life. This holds true even at high linear and rotative speeds. And you'll like the flexibility silent chain gives your design. From fractional to thousands of hp, you get space-saving narrow widths . . . long or short center operation . . . ratios up to 10 to 1.

Ask your nearest Link-Belt office for complete design data. Test drives can be quickly supplied.

LINK-BELT

SILVERSTREAK SILENT CHAIN DRIVES

LINK-BELT COMPANY: Plants: Chicago, Indianapolis, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle, Toronto, Springs (South Africa), Sydney (Australia). Sales Offices in Principal Cities. 13,244

LIFT FROM HARNISCHFEGER

– get the mo$t for your Zinc Die Ca$ting Dollar!

Take a page from Harnischfeger's success story on their Zip-Lift – the result of a determination to produce a small electric hoist (capacities up to 2000 lbs.) which would compare – point for point and dollar for dollar – with existing higher priced hoists on the market. The ZINC Die Castings pictured at the right played no small part in achieving that elusive design objective – high quality at low cost.

The housing for the Zip-Lift control unit (see open view above) is formed with the two larger ZINC Die Castings illustrated. The five smaller castings are pulleys and other operating components. While all of these parts are complex in shape, the economies of die casting are most apparent in the housing half at the extreme right. No elaborate secondary operations are required to prepare this part for assembly. All holes, recesses and bosses are cored or cast in the die casting operation. The as-cast dimensional accuracy insures perfect fit of the "innards" and the inherent strength of ZINC Die Castings safeguards the unit from abuses in service.

For many other examples of die casting economies, ask us – or any commercial die casting company – for a copy of our brand new booklet "The End Uses of ZINC Die Castings".

The New Jersey Zinc Company
160 Front St., New York 38, N. Y.

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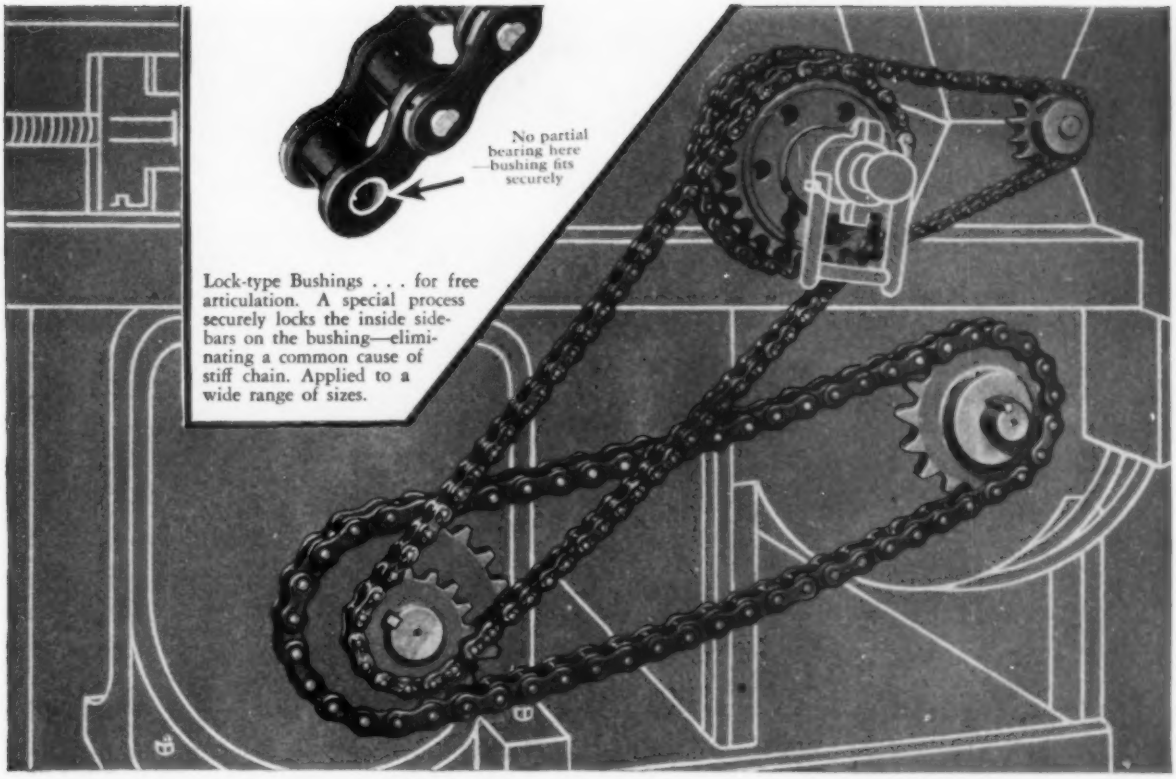
ZINC
FOR DIE CASTING ALLOYS

The Research was done, the Alloys were developed, and most Die Castings are based on
HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC


No partial bearing here—bushing fits securely
Lock-type Bushings . . . for free articulation. A special process securely locks the inside sidebars on the bushing—eliminating a common cause of stiff chain. Applied to a wide range of sizes.

Look to LOCK-TYPE BUSHINGS for longer roller chain life

Just one of many engineering extras you get from LINK-BELT

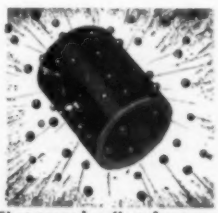
FOR drives that must operate under severe conditions, it will pay you to use Link-Belt Precision Steel Roller Chain. Lock-type bushings and the many other Link-Belt engineering extras add up to *built-in* extra life. Whether it's for power transmission or conveying, you are assured of a positive, flexible, economical chain . . . with high sustained efficiency. For complete information, see your nearby Link-Belt sales representative, or write for Engineering Data Book 2457.

LINK-BELT

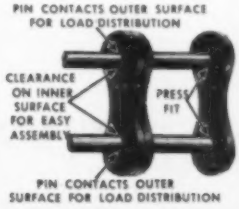
ROLLER CHAINS & SPROCKETS

LINK-BELT COMPANY: Plants: Chicago, Indianapolis, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle; Scarboro, Toronto and Elmira, Ont. (Canada); Springs (South Africa); Sydney (Australia). Sales Offices in Principal Cities. 13,330-B

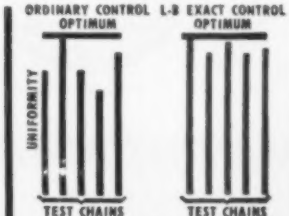
Don't overlook these other LINK-BELT extras



Shot-peened rollers have extra fatigue life under impact.

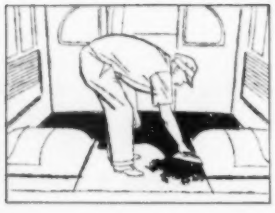

PIN CONTACTS OUTER SURFACE FOR LOAD DISTRIBUTION
CLEARANCE ON INNER SURFACE FOR EASY ASSEMBLY
PRESS FIT
PIN CONTACTS OUTER SURFACE FOR LOAD DISTRIBUTION

Couple and uncouple multiple-width chains more easily.



Closer heat treat control helps attain greater uniformity.

Setting safer paths for little feet



The designers and manufacturers of America's school buses place great emphasis on all details pertaining to passenger safety. Safe, non-slip flooring is one of the essentials—and Superior Coach Corporation at Lima, Ohio, uses a 3M Adhesive to anchor floor matting to the steel floors of their school buses.

Superior has standardized on a 3M rubber-based adhesive for this operation because they need fast application and a quick, strong bond that will stand up under vibration, temperature changes and strong cleaning solutions.

See what adhesives can do for you . . .

3M's rubber-based adhesives provide a fast, low-cost way of joining a variety of materials. Like to see some actual examples of what other companies are doing with 3M adhesives? Ask your 3M salesman for a copy of our new Design Handbook, or write today to 3M, Dept. 49, 417 Piquette Ave., Detroit 2, Mich.

3M COMPANY

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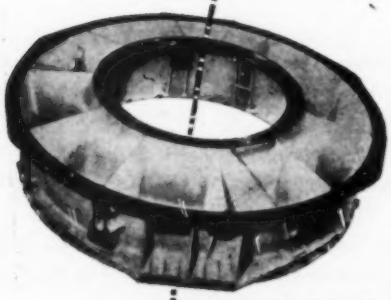
Ductalloy® castings make "impossible" parts producible



Wright J-65 jet engine main bearing support... impractical to machine from one piece. Readily produced as a weldment of two Ductalloy precision castings.

This highly stressed part secures the 7,200-lb. thrust Wright J-65 jet engine in the aircraft, carries major structural members ahead of and behind it, and mounts a main shaft bearing in its center. Air roars between the carefully contoured inner and outer rings.

As originally hogged out from an aluminum forging on an experimental basis, this part required some 1200 hours of machining—impractical for volume production. Redesigned by Curtiss-Wright Corporation's Wright Aeronautical Division as a weldment of two Ductalloy precision castings, it requires only simple turning and facing plus 25 ft. of welding to assemble the ten interconnecting stainless steel struts. An "impossible" part for volume manufacture in other metals which would meet specifications, it is rendered readily producible in Ductalloy—Brake Shoe's ductile cast iron that combines high strength with the casting and machining qualities of gray iron.

YOUR PROBLEM—Ductalloy may solve your problem if it involves economical production of complex metal shapes that are difficult to cast in steel, expensive to forge, or lacking strength in gray iron. Brake Shoe's experience, research laboratory and experimental foundry are available to help you best utilize its unusual combination of characteristics. Write for your copy of this new technical bulletin today.

Ductalloy castings are made by: BRAKE SHOE & CASTINGS DIVISION
ENGINEERED CASTINGS DIVISION

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For Removing RUST and SCALE

"ALKA-DEOX" DERUSTING PROCESS — An alkaline electrolytic process for rapid, removal of rust and scale from steel, cast iron and malleable iron. Operates at room temperature. No attack on basis metal. Uses Enthone Compound 134.

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"DESCALER 2A" — POWDERED ACID PICKLING COMPOUND. A powdered acidic compound added to water to make pickling solutions for iron and steel. Safer to handle than sulphuric acid. Gives controlled acidity to prevent overpickling.

"ACTANE 33" — POWDERED COMPOUND REPLACES HYDROFLUORIC ACID. A dispersing agent added to acid pickles to remove colloidal and siliceous films from metals. Also an additive for sulphuric and nitric acid pickles to promote faster pickling of stainless steel, aluminum and titanium.

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"INHIBITOR 8" — STOPS ACID ATTACK ON STEEL. An all-purpose inhibitor for acids including sulphuric and hydrochloric acids to stop attack on steel during pickling.

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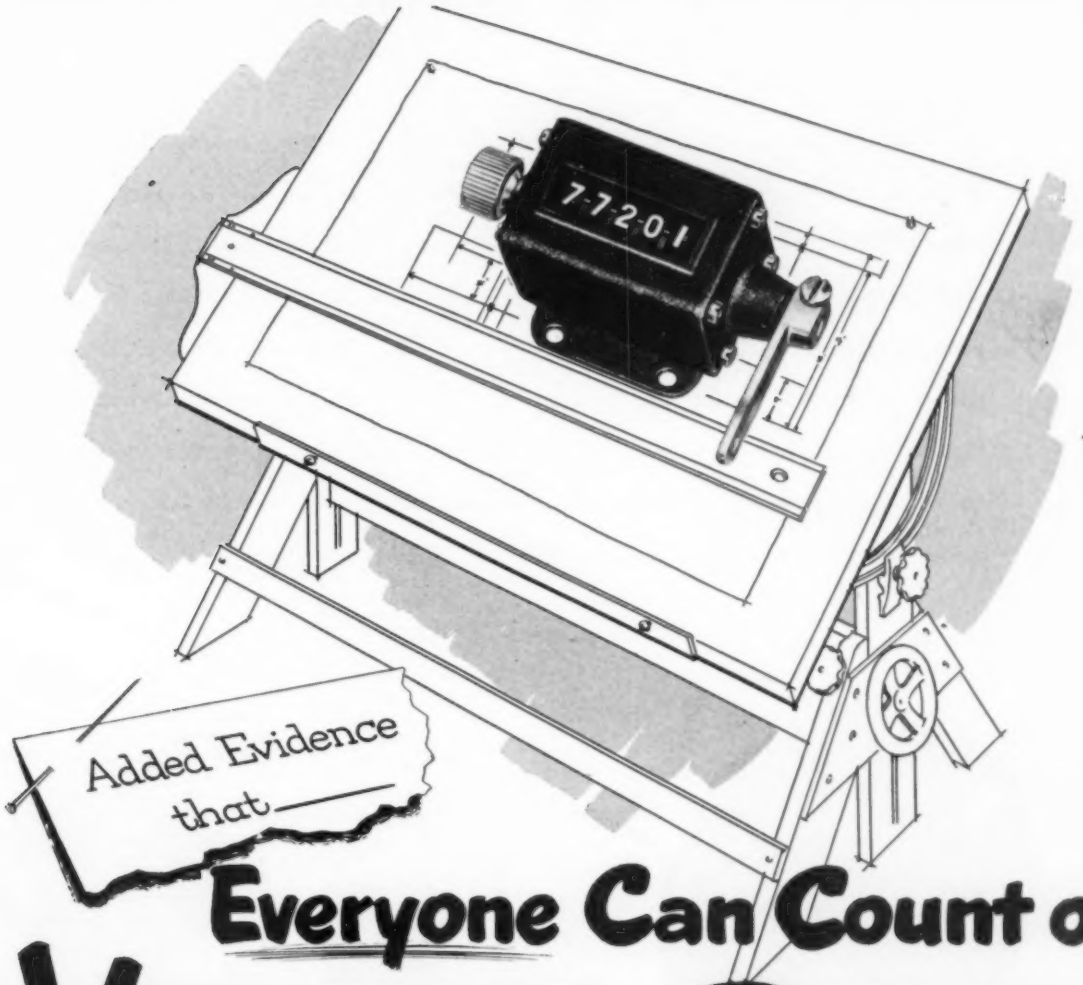
Nothing You Build Into Your Product *Can Count for More!*



Added Evidence that—

Everyone Can Count on VEEDER-ROOT

This compact Reset Counter, shown actual size, is a standard built-in part of many makes of business machines, cameras, coin machines, compressors, die casting machines, hay balers, laundry equipment, plastic molding machines, punch presses, shoe machines . . . and what have *you*? It counts turns, strokes, pieces or other units of performance and output . . . supplying facts-in-figures that help toward closer *Count*rol. Find out how *your* product can give your customers a *new usefulness*, with these or other Veeder-Root Counters for mechanical or electrical operation. Write:

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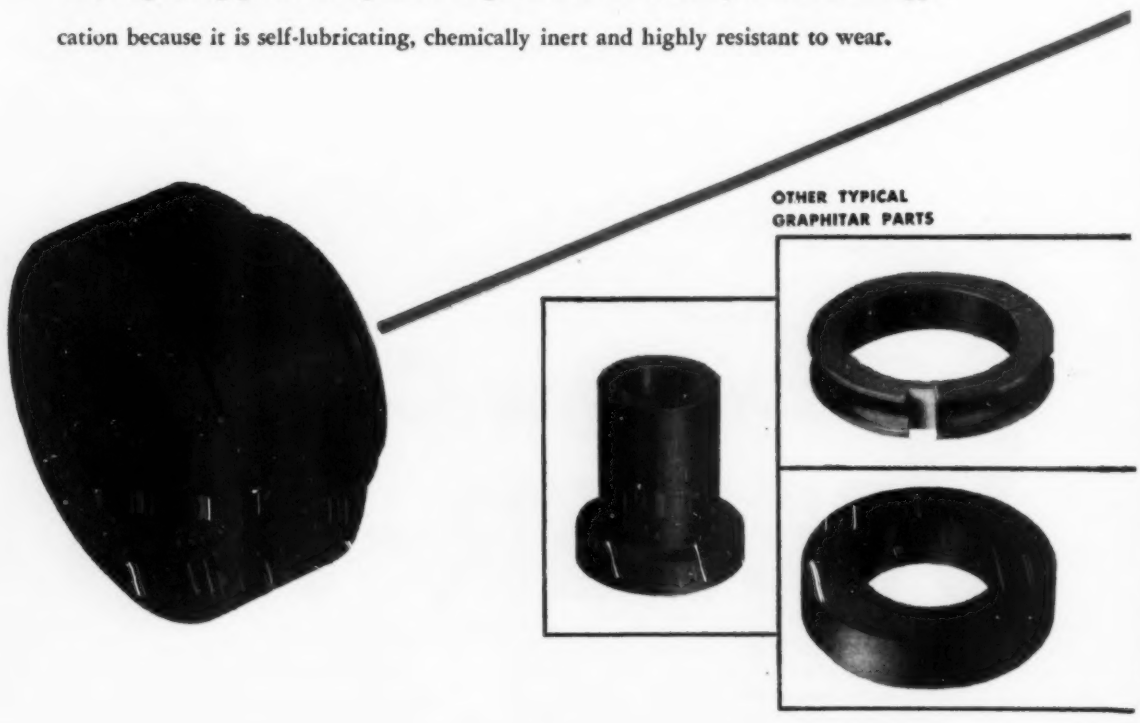
"The Name that Counts"

GRAPHITAR® assures

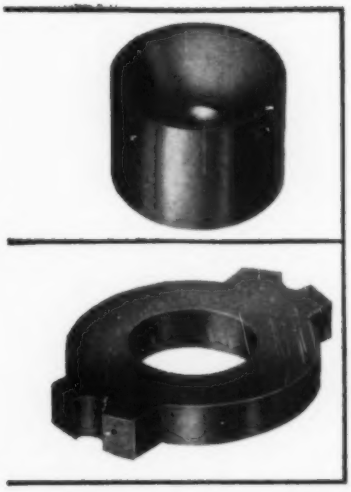
the mechanical seal that rotates with the shaft

Dura Seal mechanical seals, made by Durametallic Corporation of Kalamazoo, Michigan, rotate with the shaft of centrifugal and rotary pumps, autoclaves, blowers, agitators and other rotating equipment to provide a pressure-tight liquid seal. They are made to operate with most any fluid, including highly corrosive acids and alkalies, at temperatures ranging from 80° F. below zero to 400° F. above zero and pressures up to 600 psi. A stationary GRAPHITAR gland insert provides an anti-frictional surface in conjunction with a hard-surfaced rotating unit of the Dura Seal. This fine combination insures tight, trouble-free, long-lasting protection against leakage. GRAPHITAR is ideally suited for this application because it is self-lubricating, chemically inert and highly resistant to wear.



THE UNITED STATES

efficiency of Dura Seal-



GRAPHITAR is a versatile engineering material produced from carbon-graphite powders, compacted under terrific pressures and fused at temperatures exceeding 3000° F. It has proved indispensable to industry in hundreds of difficult applications.

- GRAPHITAR can be formed in relatively complicated shapes and ground to tolerances as close as .0005".
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- GRAPHITAR is practically unaffected by high speeds, high pressures or temperature extremes.
- GRAPHITAR is highly resistant to wear.
- GRAPHITAR is chemically inert and will not corrode even when exposed to concentrated acids.
- GRAPHITAR is self-lubricating and needs no oiling.
- GRAPHITAR is available in virtually unlimited quantities.

Just released! New 72-page GRAPHITAR catalog packed with facts, profusely illustrated. Write for your copy today.

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GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW, MICHIGAN

They've got what it takes

Take a look at what's behind this nameplate and you'll see a motor that has what it takes to give service "beyond the call of duty."

HOOVER Heavy Duty Electric Motors

PRECISION—woven into every foot of wiring, fitted into every moving part—gives Hoover motors the stamina to stand up under the grind of continuous operating cycles—to take the punishment of frequent starts and stops.

"Torture the truth" out of a Hoover—overload it, abuse it, give it every test, under every adverse condition you might expect to be required of your motor driven equipment—and it comes up asking for more.

That's why Hoovers so seldom need service. But when service is needed it's ready *wherever the motor is.* Hoover's own service agency system is world-wide.

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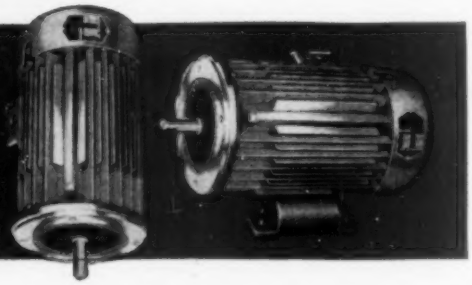
Totally enclosed Hoover motors are made in a wide range of standard NEMA frame sizes, vertical and horizontal face mounted types. The same quality construction in a full line of open types of capacitor and polyphase motors up to 5 h.p.



New Totally Enclosed Motor

Trouble sealed out. Fully enclosed construction defies moisture, dust, oil and abrasive grit.

1 Cooling fins rapidly dissipate heat by convection and conduction as air is blown at high velocity—and without obstruction—over the motor frame.

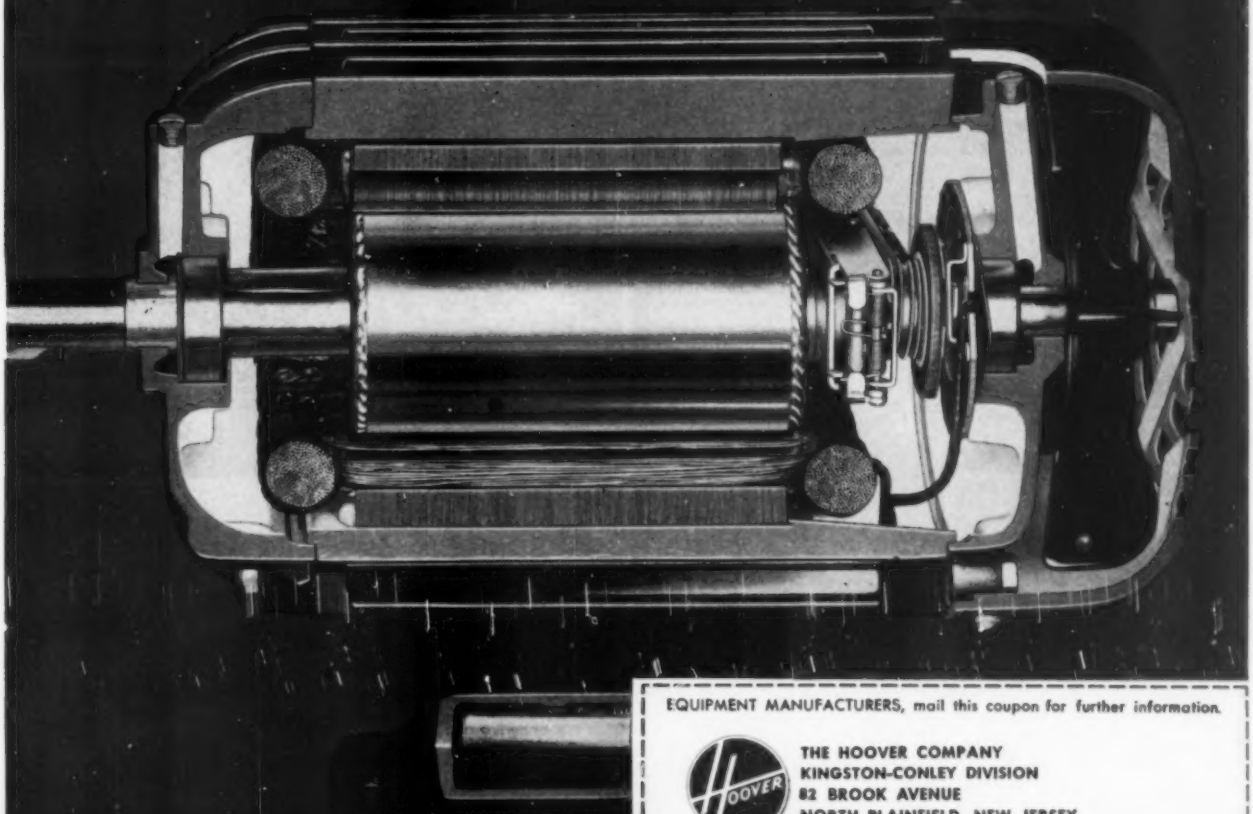
2 fan blows dust and dirt away. No blind passages to collect it. Easier to clean and keep clean even in wet or oily locations.

3 External fans on enclosed motors can be exposed without removing motor from its application. Fans are dynamically balanced.

4 with provision for easy in-service relubrication to assure long life. Shielding prevents entry of foreign particles. Ample grease reservoirs give protection of an extra seal.

5 are *individually tested* (not just spot checked) both before and after assembly. They are solidly braced with a high-grade baked varnish. Stator slots are lined with cellulose acetate paper that effectively resists high-voltage breakdown.

6 is precision balanced to assure smooth, quiet, vibrationless operation. Runs free and cool—no lag, no drag. Accurately skewed rotor slots and close machining tolerances makes a motor that runs quietly and with uniform torques.



7 on single phase motors is mounted in base for extra protection, extra compactness.

8 Hoover motors have more horsepower per pound and per cubic-inch of space. Ribs not only give extra cooling surface but give unusual strength to frame.

EQUIPMENT MANUFACTURERS, mail this coupon for further information.

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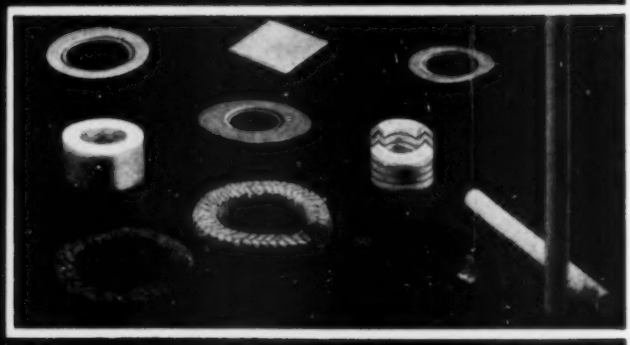
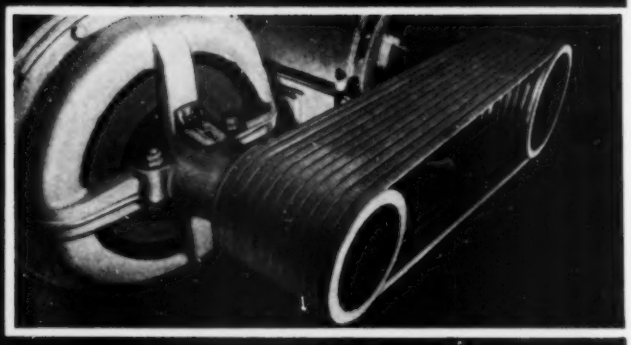
Design people find Raybestos-Manhattan engineering service helpful on problems involving Asbestos, Rubber, Sintered Metal and Teflon* Products





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Fan Belts and Radiator Hose

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Industrial Drive Belts

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Raybestos-Manhattan makes a broad line of Teflon packings and gaskets for use with chemicals. Teflon products are practically inert chemically and will not react with strong acids or caustics. R/M is also ready to meet your specifications for Teflon rods, sheets, tubes, tape and specially fabricated parts. The highly diversified R/M line includes packings for use against air, gas, water, steam, oil, solvents, foods and hydraulic fluids. R/M is also the manufacturer of an extensive line of asbestos textiles.

**Du Pont trade-mark for its tetrafluoroethylene resin*

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R/M

Here are 10 special

Top—"G" Type Undervoltage Trip
"F" Type Breaker
"J" Type Breaker

Bottom—"E" Type Breaker
550 Volts, D-C; "G" Type Blowout Arc Chute
"G" Type Auxiliary Switch
"J" or "K" Type Shunt Trip

ways Westinghouse AB Circuit Breakers can do more for you

. . . to give you greater flexibility for panel, switchboard or control cabinet requirements

Westinghouse can help you build better equipment for bigger sales. How? By providing new, low-cost ways of offering your customers greater circuit capacity in less space, special breakers for tough applications, and modifications and accessories for unusual operating conditions.

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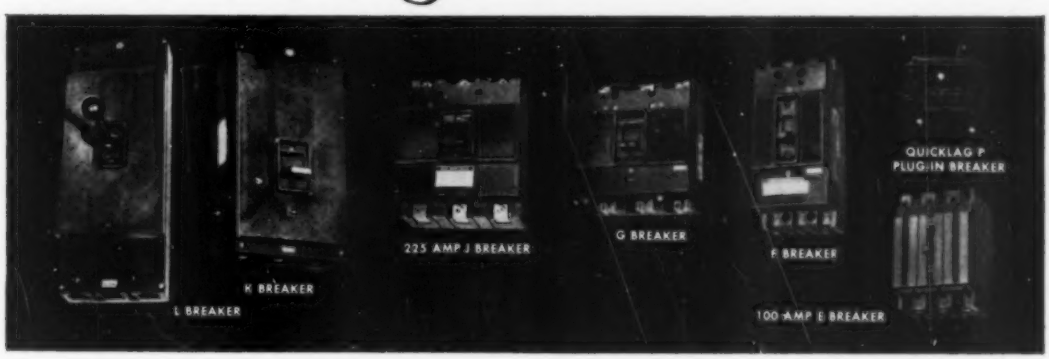
4. New Visible Blade De-ion Switch Line—30, 60, 100, 200-amp ratings—smaller, but with higher interrupting capacities than other devices of comparable ratings.
5. P-1 Circuit Breaker—high vibration and impact resistance; for PCC and railroad cars, locomotives, rapid transits, trolley coaches.
6. New Ground Current Limiter—stops dangerous current leakages at from 3 to 20 amps independently of breaker trip elements—for greater safety in mines and damp locations.
7. Undervoltage Protection—trips breakers automatically when line voltage drops to approximately 50% or less than normal.
8. Shunt Trip—trips breaker instantly from remote point; has solenoid-plunger combination with cutoff switch to break actuating current after operation.
9. Remote Control—provided by motor operator on K and L Breakers.
10. Breakers for Unusual Conditions—specially selected and treated parts are used in breakers for extremely moist or corrosive atmosphere, or where fungus growths are prevalent.

These developments in safer, more complete circuit protection pin point many modern design, function and assembly problems. But they are only a few of literally scores of circuit devices available to you.

Call your Westinghouse Representative, or write for booklet B-5407, Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa. J-30160

YOU CAN BE SURE...IF IT'S

Westinghouse



Now-Standardize on TAPER-LOCK

Now, for the first time, you can have all the benefits of standardizing on a truly modern method of mounting wheels on shafts . . . through the famous Dodge patented Taper-Lock design.

The time-saving, cost-cutting performance of Dodge Taper-Lock . . . already proved in millions of installations of Taper-Lock Sheaves, Couplings and Conveyor Pulleys . . . is now available in a complete line of Taper-Lock Sprockets with Dodge Roller Chain.

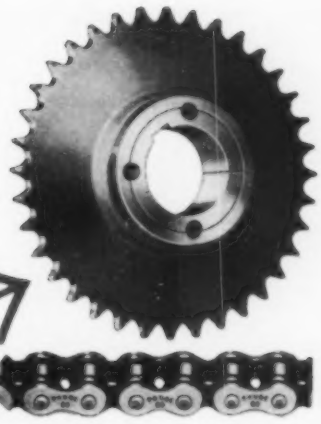
The bushing pictured here fits into the hub of every one of the Dodge products shown—sprockets, sheaves, couplings, conveyor pulleys. Both tapered bushings and hubs are precision machined to achieve perfect interchangeability. The result is less down-time on machines, simpler maintenance, reduced inventories. Taper-Lock gives you an unmatched opportunity to lower your costs and keep production rolling.

Dodge Taper-Lock grips the shaft for the full length of the bushing—holds with the firmness of a shrunk-on fit, yet comes off easily, quickly.

Taper-Lock's exclusive advantages were never more strikingly proved than in the new line of sprockets recently introduced by Dodge. For Taper-Lock brings to sprockets a new "off-the-shelf" availability. No time-consuming and costly reboring, key seating, drilling and tapping for set screws, needed to fit them to the shaft! Dodge Taper-Lock is available in both driver and driven sprockets from No. 40 to No. 100, up to 112 teeth. Taper-Lock bushings to fit shafts from ½" to 10" are available from stock.

Consider carefully the cost-saving advantages you get by standardizing on Taper-Lock — the modern method of mounting wheels on shafts. For further information, call your Dodge Distributor, or write the factory.

DODGE MANUFACTURING CORPORATION, 1200 Union Street, Mishawaka, Indiana



TAPER-LOCK SPROCKETS and Dodge Quality Roller Chain

— THE MODERN WAY TO MOUNT SPROCKETS

— THE MODERN WAY TO MOUNT SHEAVES

TAPER-LOCK SHEAVES

— THE MODERN WAY TO MOUNT COUPLINGS

TAPER-LOCK COUPLINGS Rigid and Flexible

— THE MODERN WAY TO MOUNT CONVEYOR PULLEYS

TAPER-LOCK SOLID-STEEL CONVEYOR PULLEYS

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory-trained by Dodge, he can give you valuable assistance on new, cost-saving methods. Look for his name under "Power Transmission Machinery" in your classified phone book.

DODGE

of Mishawaka, Ind.

Why pay for unneeded precision in ball bearings?

In many applications where speeds and loads are moderate, you don't need a precision bearing. When this is the case, Schatz "Commercial" Ball Bearings can cut your costs by as much as 85%—*without any sacrifice in operating efficiency.*

Why are savings like this possible? Because "Commercial" Ball Bearings are designed to wider tolerances than precision bearings...because they are available unground, partially-ground, or fully-ground. And, because, in almost all cases, cages are not used.

If you have an application where speeds and loads are moderate, it will pay you to look into Schatz "Commercial" Ball Bearings. To learn how you may save, write for literature described below.

THE SCHATZ MANUFACTURING COMPANY
6758 Fairview Avenue, Poughkeepsie, New York

Schatz "Commercial" Bearings used on these products

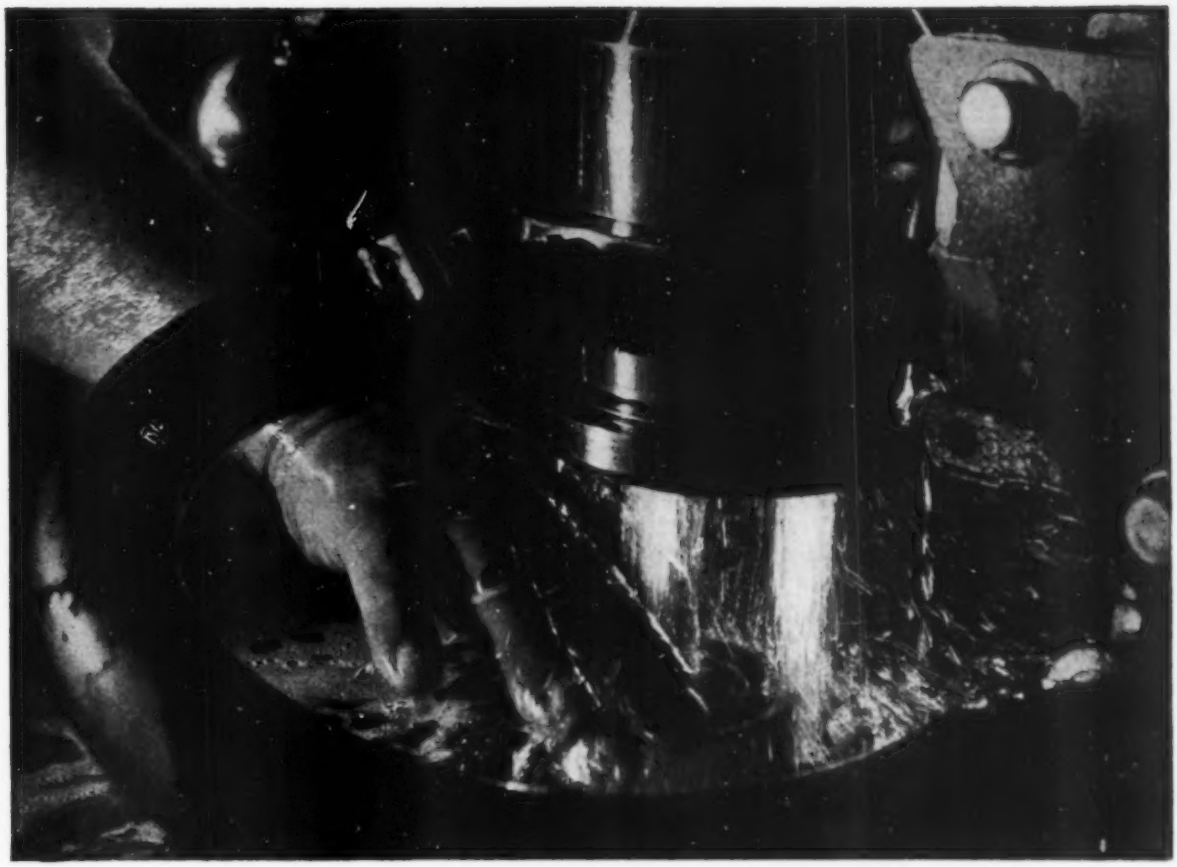
Dishwashers • Outboard motors
Automobile steering mechanisms
Elevators • Box machinery
Office equipment
Flexible shafts • Lawn mowers
Masonry cutting equipment
Textile machinery • Farm equipment
Laundry equipment

What about your product?

The oldest, largest manufacturer of "Commercial" ball bearings

SCHATZ
"Commercial"
BALL BEARINGS

Technical literature available:
Schatz Catalog 11 contains drawings and specifications of Schatz Ball Bearings.
Technical Bulletin tells how to determine proper type and size "Commercial" Ball Bearing for various speeds and loads.
Nylon Bearing Parts discusses advantages of nylon parts in "Commercial" bearings.



Every day is washday here

AT ONE OF THE LAST stops on the production line, Federal Ball Bearings are scrubbed cleaner than a boy's face on Sunday morning.

This is a privilege accorded to only the finest. To reach this stage, the bearings have had to pass dozens of exacting tests.

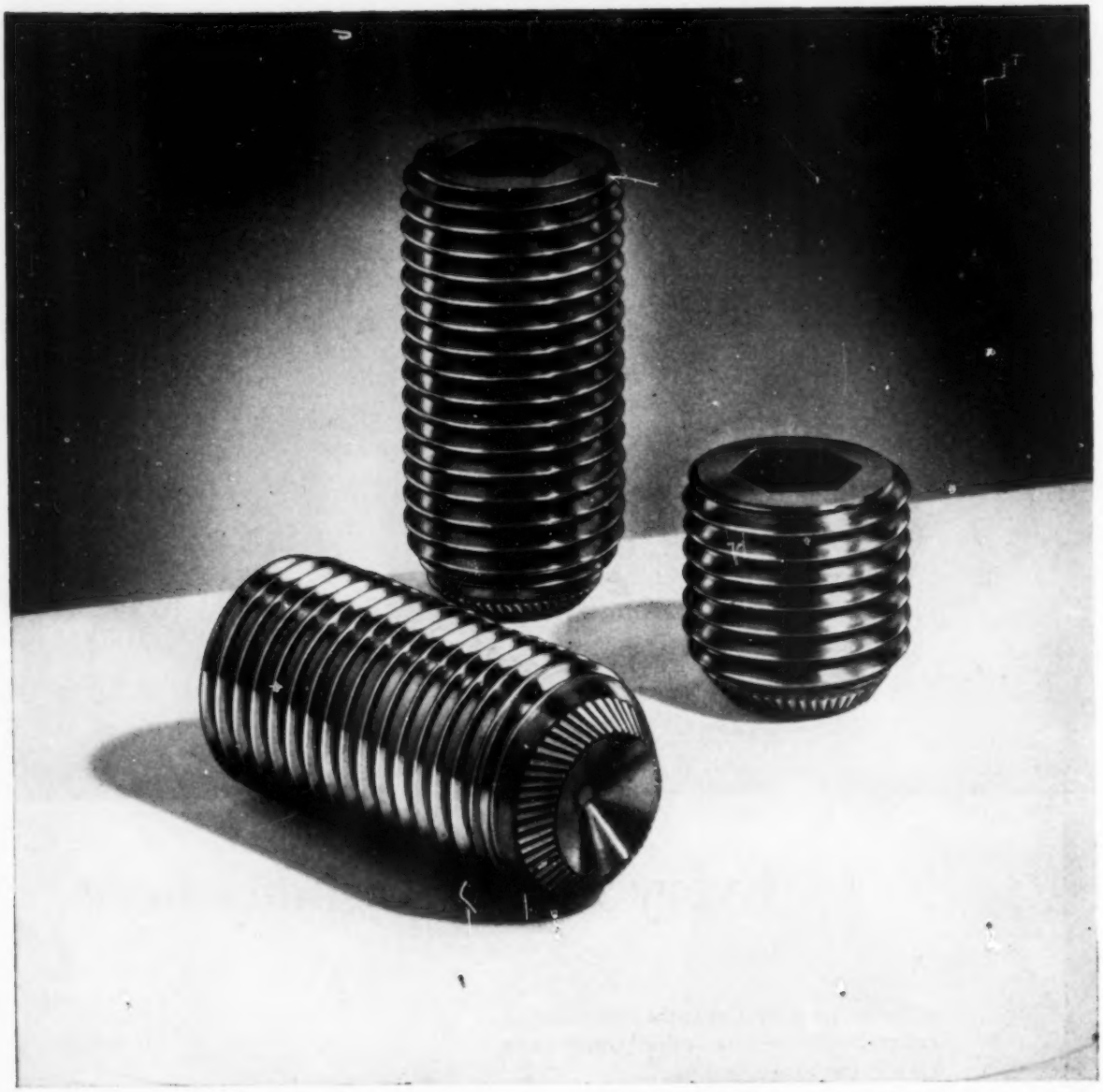
But come "washday," they are first placed into a specially-designed washer. Swirling, whirling suds immerse the bearing... wash away grit and dust. Next step is to blow the bearing clean by liquid pressure. Then it is washed again—several times—as needed. Only spotlessly clean bearings move on for protective lubrication and packaging.

A minor step in the manufacture of a bearing? Not at all. All steps are important at Federal. That's why you can always be sure of top-notch performance from every Federal Ball Bearing.

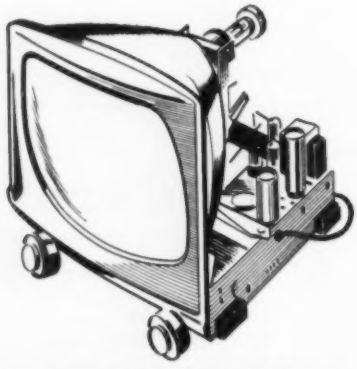
The Federal Bearings Co., Inc., Poughkeepsie, N. Y.

Federal
Ball Bearings

One of America's Leading Ball Bearing Manufacturers



UNBRAKO SELF-LOCKING SOCKET SET SCREWS feature the following advantages: knurled cup point that won't work loose; accurate hex socket for nonslip, positive drive; fully formed threads—Class 3 fit; heat treated alloy steel for strength; standard sizes—#4 to 1"—in a full range of lengths.



USE UNBRAKO SELF-LOCKING SOCKET SET SCREWS wherever ordinary cup point set screws are used... on radios, television sets and electronic equipment.

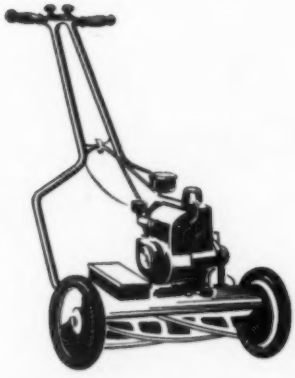
On refrigerators, washers, other household appliances

9 times out of 10 a standard UNBRAKO will do the job

A special socket screw may not be necessary, a standard UNBRAKO usually does the same job—much cheaper. Your local industrial distributor stocks Standards. He gives immediate attention to your requirements, and such extras as special delivery to your plant. Write for a copy of UNBRAKO Standards. STANDARD PRESSED STEEL Co., Jenkintown 28, Pa.

UNBRAKO® SOCKET SCREW DIVISION

SPS
JENKINTOWN PENNSYLVANIA



On power mowers, power saws and other power tools.

UNBRAKO Standards—as listed in the SPS Catalog—are stocked by leading industrial distributors everywhere.

Many a New Cold-Formed Shape Starts with a Customer's Idea

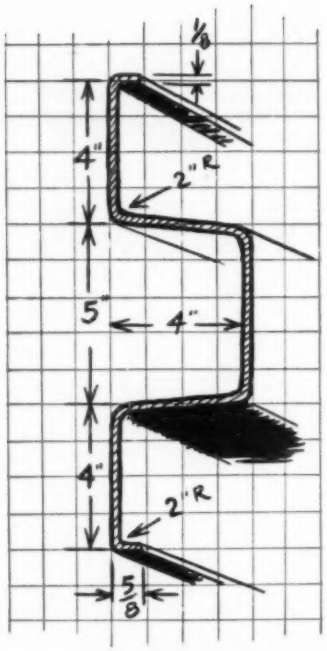
Often an inquiry and a rough pencil sketch submitted by a manufacturer lead to two things: (1) a new, cost-cutting application for Bethlehem Cold-Formed Shapes, and (2) a satisfied customer.

Lately we've formed and, in some instances, fabricated shapes for such diverse uses as door tracks, radiant baseboard sections, parts for engine containers, hatch covers for sea-going vessels, and cold-formed storage racks. Ideas for these applications came from our customers.

Bethlehem Cold-Formed Shapes are regular or irregular shapes formed cold from strip, sheet or plate steel. They are uniform in thickness, with a surface relatively free from scale. They have a high strength-to-weight ratio. We make them on presses, brakes or rolls in all gages from 5 to 24, and in virtually any length.

In analyzing your shop operations, perhaps you'll find a new use for Cold-Formed Shapes. Our engineers have the skill and experience to turn your idea into a practical and economical product.

Ask the nearest Bethlehem sales office for a copy of our booklet on Bethlehem Cold-Formed Shapes.



BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

SO SIMPLE

NO PINS • NO PIVOTS • NO BEARINGS

No Wonder There's No Trouble

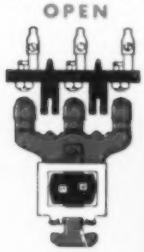
In any device it's the moving parts that are the troublemakers. The more moving parts . . . the more chances for trouble.

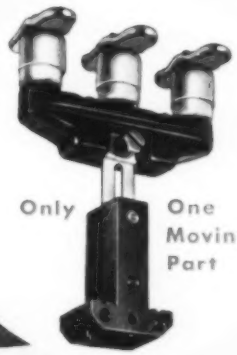
Most motor starters have lots of moving parts like pins, pivots, bearings, and linkages. But . . . Allen-Bradley Bulletin 709 solenoid starters and contactors have ONLY ONE MOVING PART . . . the solenoid plunger which carries the movable contacts. No switch could be simpler . . . nor more trouble free. The silver alloy contacts need no filing or dressing. They are always in good operating condition.

The Bulletin 709 general purpose enclosures, shown below, have a bonderized, black enamel exterior finish that is corrosion resistant. The white interiors make installation and inspection easy in dark places. All switch parts have a "quality" finish. In fact, you cannot buy better "quality looking" control.

Special enclosures are available for every kind of service condition. These across-the-line starters can also be furnished in "open type," without enclosures, for mounting in machine base. Let us send you our catalog!

CONTACTOR OPEN





CONTACTOR CLOSED

Send for Illustrated Bulletin

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.

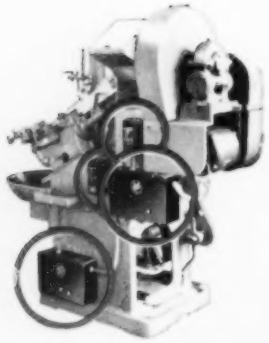
COMPLETE LINE

Allen-Bradley Bulletin 709 Across-the-line Starters are listed for 3-phase motors up to 600 hp, 440-550 v. All starters have accurate relays for overload protection.

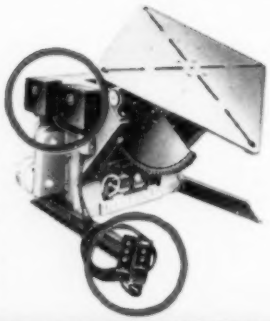
ALLEN-BRADLEY

TROUBLE FREE MOTOR CONTROLS

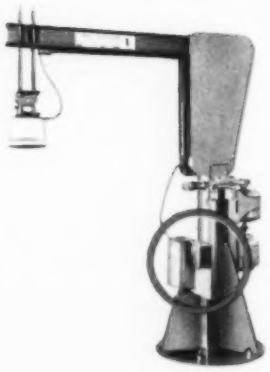
7-53-M2



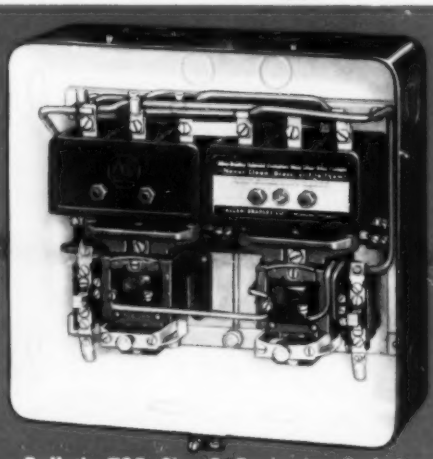
Two Allen-Bradley Bulletin 705 solenoid operated reversing switches on Waterbury-Farrel screw thread rolling machine.



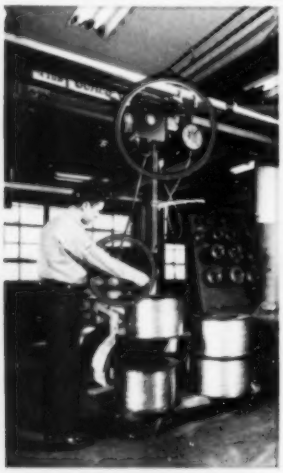
Two Allen-Bradley Bulletin 705 reversing switches on Ransome welding positioner. Push button stations are attached to flexible control cable.



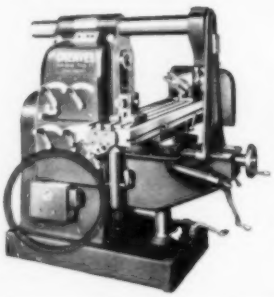
Morris-Wheeler pillar type jib crane equipped with Allen-Bradley Bulletin 705 reversing switch to control the horizontal swing of the crane.



Bulletin 705, Size 2, Reversing Switch.



Bulletin 705 reversing switch on Conco ¼ ton electric hoist for lifting copper wire reels in wire mill.



Bulletin 705 reversing switch for Greaves No. 2 milling machine. Master push button station is at top of the milling machine.

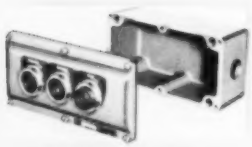
Mercer materials handling hoist equipped with Allen-Bradley Bulletin 705 reversing switch.

TROUBLE FREE REVERSING SWITCHES for 1001 APPLICATIONS

When you have an application for reversing controls, make the installation trouble free by installing Allen-Bradley Bulletin 705 reversing switches. These solenoid operated switches are mechanically and electrically interlocked for complete safety to man, motor, and machine.

Bulletin 705 reversing switches have maintenance-free silver alloy contacts. Accurate and dependable relays protect the motor against overload. Can also be furnished without overload protection. Enclosures are available for every kind of waterproof, dustproof, and explosion-proof service.

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. 7-53-R



OILTIGHT CONTROL STATIONS

Bulletin 800T oiltight push button stations for reversing control are available in many combinations of push buttons . . . normally open or normally closed . . . with or without pilot lights . . . in any horizontal or vertical arrangement.

A-B Quality

ALLEN-BRADLEY

BULLETIN 705 REVERSING SWITCHES

QUALITY

Facts about *HELI-COIL* inserts you should know

What they are

Heli-Coil* screw thread inserts are precision formed coils of stainless steel or phosphor bronze wire. Wound into tapped holes, they form permanent, non-corrosive, strip-proof threads of astonishing strength. Available for National Coarse, National Fine and Unified threads, pipe threads and spark plug threads. They are made in all standard sizes and lengths for assemblies requiring Class 3, 3B, 2 or 2B fits.

What they are for

AS ORIGINAL COMPONENTS: *Heli-Coil* inserts are used to provide stronger, lighter fastenings, corrosion-proof, wear-proof threads in all assemblies.

FOR PRODUCTION SALVAGE: When conventional tapped holes are damaged in production, restore them on the line with *Heli-Coil* inserts. Get better-than-original strength with no increase in screw size and no tell-tale signs of rework.

FOR SPEEDY REPAIRS: When tapped threads wear, strip or corrode in service, renew them in minutes on location in shop or field with *Heli-Coil* inserts. No welding—no plugging—no secondary machining—no oversize screws.

How they work

Holes are drilled and tapped as you do for ordinary threads—then *Heli-Coil* inserts are wound into tapped holes by hand or power tools. Install in a few seconds, assure thread protection forever. Can be used in any metal wood or plastic.

No other method is so simple, effective and practical.

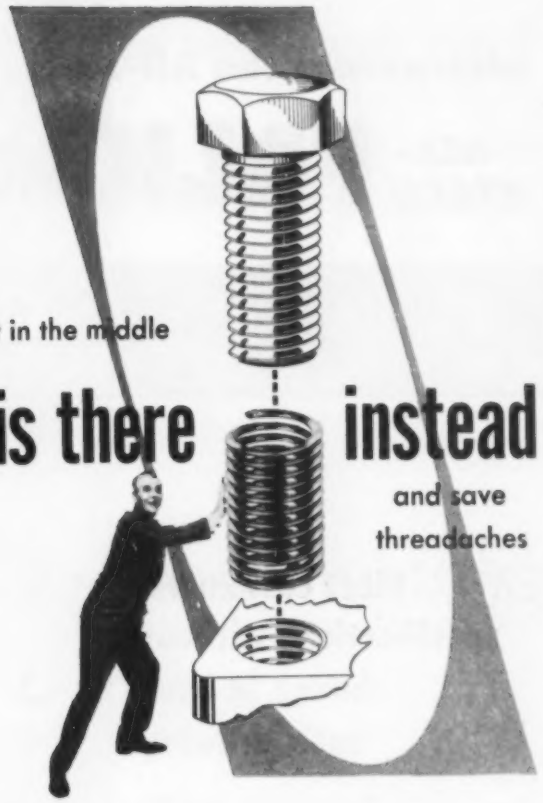
What they do for you

Heli-Coil inserts *save money* because they strengthen threads and make *fewer* smaller fastenings do the same holding job. They make *lighter* bosses and flanges practical and they *save weight* in two ways: (1) by permitting use of cap screws, instead of bolts and nuts; (2) by allowing use of smaller, shorter, fewer cap screws. *Heli-Coil* inserts *protect* your product from thread wear, galling and stripping for life in every kind of metal, in plastics or wood. They preserve customer good-will by preventing product failure, due to thread fault. *Heli-Coil* inserts improve the end product, cut rejects, salvage threading errors.

Best time to put *Heli-Coil* inserts benefits to your use is right at the designing board, as many leading manufacturers are doing. But to convince you of their many advantages ask for a working demonstration right on your production line. Write today! Complete information and engineering data is available in the *Heli-Coil* catalog. Use Coupon!

*Reg. U. S. Pat. Off.

Approved for All Military and Industrial Uses



Sales demanding "twice the product at half the price"? Does production want "half the cost and half the time" on the production line? Where are you? Caught in the middle?

You can be a hero to both sales management *and* production management by telling them about *Heli-Coil** Screw Thread Inserts.

These precision formed inserts of stainless steel or phosphor bronze wire make vastly stronger threads in metal, plastics, and other materials. So much stronger that you can safely use smaller and fewer and shorter cap screws—thinner sections, lighter bosses. Thus costs are reduced, production simplified. And threads cannot strip, corrode or gall—they never wear out.

Learn how other designers are using *Heli-Coil* Screw Thread Inserts. Get the technical data you need to apply them to your "threadaches." Use the coupon—now!

*Reg. U. S. Pat. Off.

HELI-COIL CORPORATION
149 SHELTER ROCK LANE, DANBURY, CONN.

☐ Send Free samples and Handbook No. 652, a complete design manual.

☐ Send Free samples and put me on list to receive "Heli-Coil", case history periodical.

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____ 2102

Incorporate the All-Motor type,

ALL-STEEL FALK Motoreducer

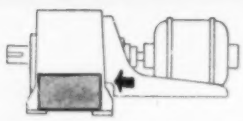
as your standard!

Meet customers' specifications without change in your basic drawing

The *all-steel,* All-Motor type FALK Motoreducer assembly can easily be modified to use overload protective coupling, brake-wheel coupling, multispeed transmission or hydraulic fluid drive. Motors with variable speed drive arrangement can be substituted for standard motor.

The All-Motor type FALK Motoreducer . . . the only complete and compact motorized reducer with a separately mounted, resilient Steelflex coupling-connected motor . . . enables the user to replace motors from his spare stock or other convenient source as required, *in minutes*—on the job!

Any make, speed, or type of standard foot-mounted motor within the unit's rating may be used (or interchanged) without modification of gear unit. Ratio of unit can be changed without modifying the motor. Ease of motor replacement and ratio change reduce over-all cost of any equipment-remodeling desired by the customer. Write for Bulletin 3104.



Every FALK Motoreducer has these "In-built" Factors—

Positive Lubrication. Large sump capacity . . . oil-tight construction assures clean lubricant . . . direct dip of revolving elements provides positive lubrication at all speeds.

Wide Speed Range. Selective ratio combinations provide output speeds from 1.5 rpm to 1430 rpm with stock gears.

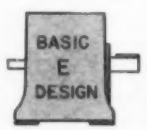
Streamlined inside and outside. Smooth, clean surfaces; machine welded construction conforms to NEMA motor frames.

Sealed Housings. Dual closures and one-way vents keep oil *in*, dust and moisture *out*. Units are splash-proof, leakproof, dustproof.

Precision Gearing. Heat treated alloy steel, precision cut and shaved helical gearing throughout . . . quiet-operating crown shaved pinions . . . taper bored gears for easy ratio changes.

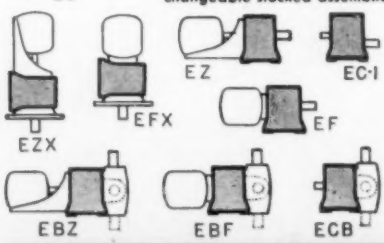
All-steel Housings. Unbreakable, strong, rigid. Generous overhung load capacities provided by wide bearing spans, large shafts and bearings.

• • • • •



EC

The basic E design permits maximum use of standardized parts . . . closer control over materials, processing, inspection and assembly . . . resulting in faster delivery from interchangeable stocked assemblies.



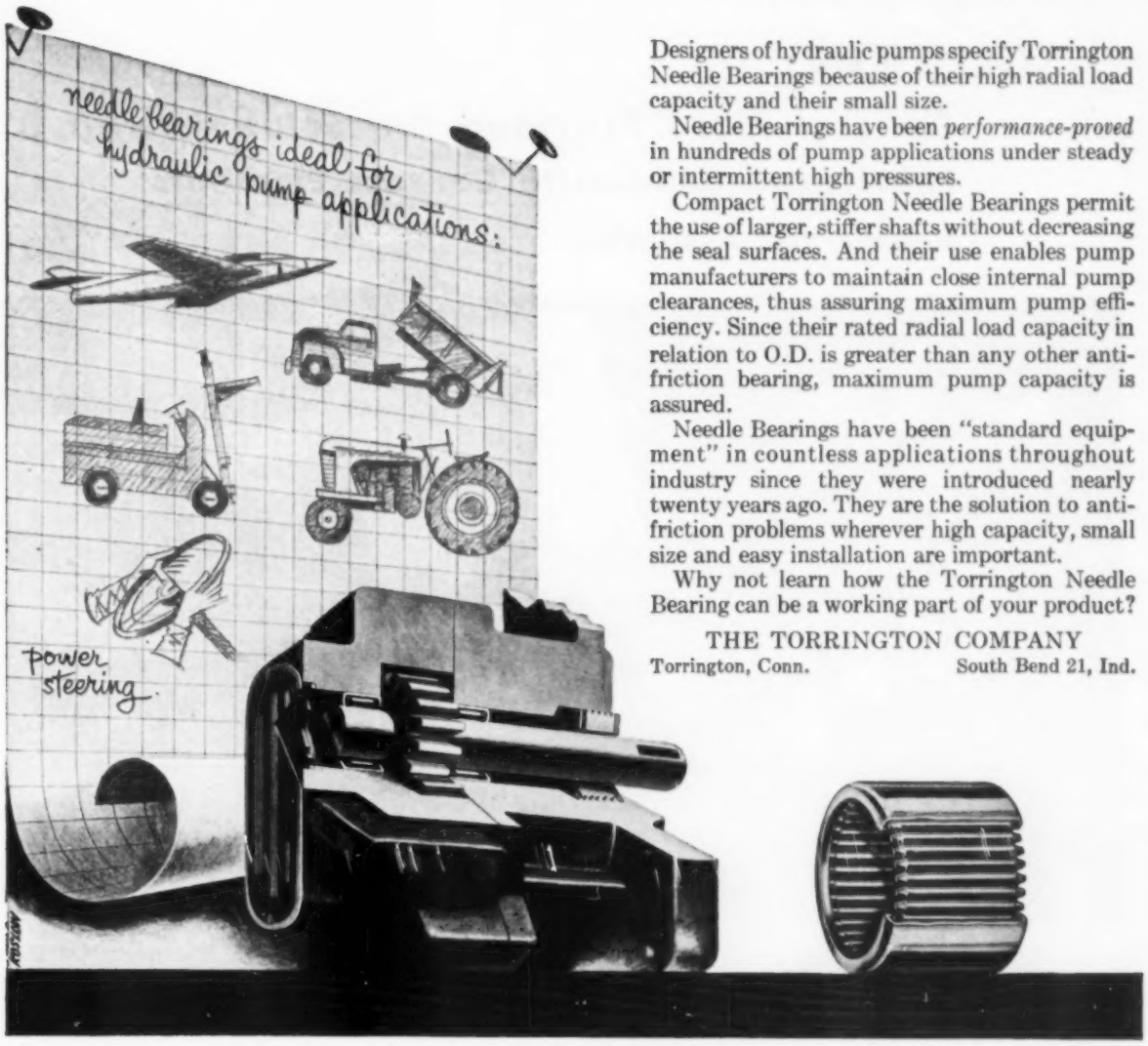
FALK ... a good name in industry

THE FALK CORPORATION · 3001 W. Canal St. · Milwaukee 8, Wis.

WRITE FOR BULLETIN 3104

Need a high capacity bearing with small size?

here's how hydraulic pump manufacturers get it with NEEDLE BEARINGS



Designers of hydraulic pumps specify Torrington Needle Bearings because of their high radial load capacity and their small size.

Needle Bearings have been *performance-proved* in hundreds of pump applications under steady or intermittent high pressures.

Compact Torrington Needle Bearings permit the use of larger, stiffer shafts without decreasing the seal surfaces. And their use enables pump manufacturers to maintain close internal pump clearances, thus assuring maximum pump efficiency. Since their rated radial load capacity in relation to O.D. is greater than any other anti-friction bearing, maximum pump capacity is assured.

Needle Bearings have been "standard equipment" in countless applications throughout industry since they were introduced nearly twenty years ago. They are the solution to anti-friction problems wherever high capacity, small size and easy installation are important.

Why not learn how the Torrington Needle Bearing can be a working part of your product?

THE TORRINGTON COMPANY

Torrington, Conn. South Bend 21, Ind.

TORRINGTON NEEDLE BEARINGS

Needle • Spherical Roller • Tapered Roller • Straight Roller • Ball • Needle Rollers

Trade-marks of some of the leading hydraulic pump and motor manufacturers whose products enjoy the benefits of Needle Bearings.

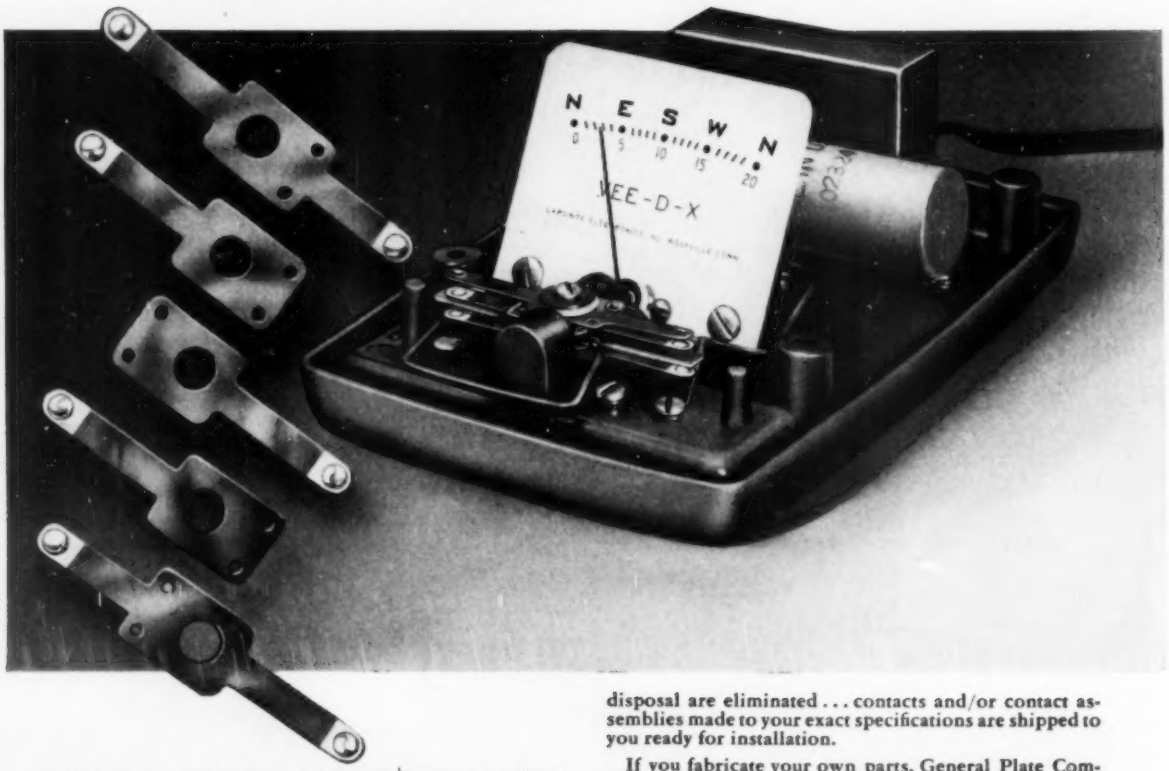
EATON · Hercules · GEROTOR · HYDRECO · Kingston · WEBSTER ELECTRIC · GW MARION · Pesco PRODUCTS DIVISION

PROBLEM:

Reduce Fabrication and Assembly Costs for Electrical Contact and Switch Blade Assemblies

SOLUTION:

General Plate Provided the Solution with Fabricated Composite Contact Elements Ready for Assembly



A leading manufacturer of Antenna Rotators required contact and switch blade assemblies for a control switch that operated two synchronized circuits. To produce the assemblies by attaching a separate contact, rivet or button to the spring blades meant high fabrication and assembly costs and special machinery.

The problem was presented to General Plate whose engineers provided an economical solution with fabricated composite contact elements ready for assembly.

The complete contact and blade elements are made from a General Plate striped composite metal. The contact is a silver alloy which gives the necessary electrical performance. The blade is phosphor bronze which provides the spring properties required for the contact supporting member.

The result — initial savings of $7,000 in assembly costs alone by using General Plate fabricated composite contact elements.

By letting General Plate fabricate your complete contact assemblies, you will save money, time and trouble ... needless equipment cost and problems of scrap disposal are eliminated ... contacts and/or contact assemblies made to your exact specifications are shipped to you ready for installation.

If you fabricate your own parts, General Plate Composite Contact Materials will still save you money and allow you to make contact assemblies superior to those produced by other methods.

The long experience, diverse facilities, and manufacturing skill of General Plate will benefit you in the form of service, quality, and savings.

Write for complete information and Catalog PR700.

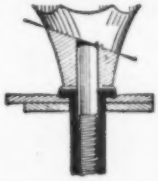
You can profit by using General Plate Composite Metals!

METALS & CONTROLS CORPORATION
GENERAL PLATE DIVISION
19 FOREST STREET, ATTLEBORO, MASS.

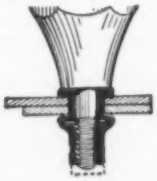
B. F. Goodrich RIVNUTS give new way to fasten leveling feet . . . cut costs!

Rivnuts provide at least 6 clean threads in one simple operation!

1 Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.



2 Rivnut is inserted—head firmly against work—tool at right angles to work.



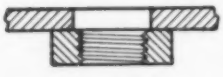
3 Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.

4 After upset, Rivnut threads are still clean and intact, ready for screw attachment.

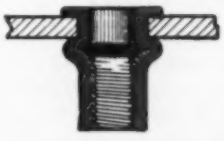
Compare these 4 methods of putting screw threads in thin sheet metal

Tapped—2 threads

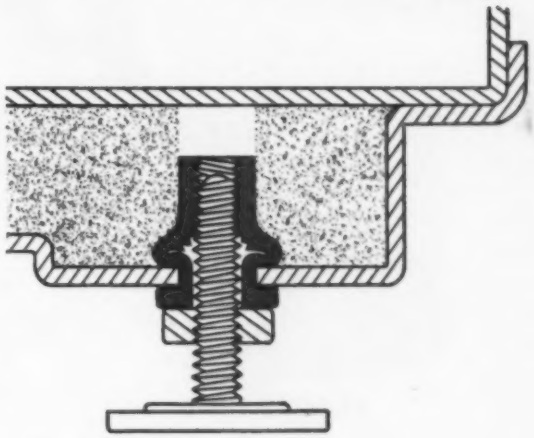
Pierced and tapped—3 threads



Projection welded—4 threads



Rivnut—at least 6 threads



APPLIANCE DESIGNERS were looking for a way to fasten leveling feet to the bottoms of refrigerators, stoves and automatic washers. The metal was too thin to tap, and welding would warp it. Besides, the threads would be ruined in the enameling process.

All these problems were solved by a B. F. Goodrich Rivnut—the *only* one-piece blind rivet with threads! Working from one side of the cabinet, one man installs the Rivnut in a few seconds. The easy-to-use power heading tool forms a bulge in the Rivnut shank—a "second head" that tightly grips the material. At least six threads remain clean to take the leveling-foot screw—more than enough to take the heavy loads. Installation is made *after* enameling without marring the finish.

Besides these advantages, the quick, simple installation of Rivnuts saves time, cuts assembly costs. For help on your fastening problem, write The B. F. Goodrich Company, Dept. A-64, Akron, Ohio.

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten TO *and* fasten WITH. Explains construction, gives proved applications . . . Write for your free copy today to the B. F. Goodrich Company, Department A-64, Akron, Ohio.

B.F.Goodrich RIVNUT *The only one-piece blind rivet with threads*

ALLIS-CHALMERS
PUMPS for Designers

Easy-to-Install pumps

Fit Most Designers' Needs

FHP pump

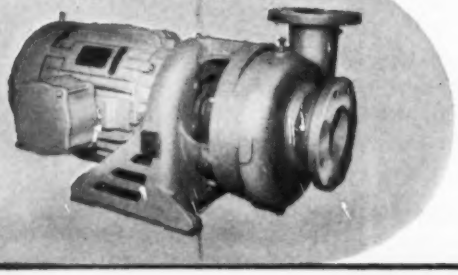
Up to 80 gpm, heads to 125 feet.

Compact pump and motor requires only two bolts for installation. Rigid construction holds alignment for longer bearing and seal life. Mechanical seal. Open impeller economy model does adequate job on many installations at very low cost. Closed impeller model for higher heads. Also available as frame-type pump for separate mounting.

Electrifugal pump

Up to 500 gpm, heads to 220 feet.

Only pump with unit-cast frame. Motor and pump are mounted on a single shaft in a one-piece rigid cast-iron frame. Alignment is rigidly held but there is plenty of space for maintenance. Installation requires only four bolts. Standard packing or mechanical seal available. Also built as frame-type pump for separate mounting.



Supporting adapter pump

Up to 2500 gpm, heads to 550 feet.

Flange motor and pump mounted on sturdy cast-iron supporting adapter. Motor and pump use same shaft. Rigidity assures vibrationless operation and long bearing life. Only four bolts required for installation. Available with standard packing or mechanical seal. Built in same ratings as frame-type pump for separate mounting.

FREE ENGINEERING HELP

YOUR ALLIS-CHALMERS PUMP REPRESENTATIVE is thoroughly familiar with the pump problems of equipment designers. He can offer you valuable time and money-saving suggestions in planning your equipment.

When you need help on a pump problem, call your nearby Allis-Chalmers District Office. Write Allis-Chalmers, Milwaukee 1, Wisconsin for Bulletins 52B7529, 52B6140 and 52B6083 describing these designers' pumps.

A-3969

Electrifugal is an Allis-Chalmers trademark.

ALLIS-CHALMERS

Another new development using

B. F. Goodrich Chemical *raw materials*

Valve made by Aero Supply Mfg. Co., Inc., Corry, Pa. Hycar rubber diaphragm molded by Vulcan Rubber Products, Inc., Brooklyn, N.Y. B. F. Goodrich Chemical Co. supplies the Hycar rubber only.
1. Completely assembled shut-off valve as used in the B-47 Stratojet. 2. Hycar rubber diaphragm in partially assembled valve 3. Hycar rubber diaphragms

"Thinking" valve needs Hycar for fast, safe refueling!

GASOLINE flow into wing tanks of B-47 Stratojets and C-124 Globemasters sometimes reaches 600 gallons per minute.

Shut-off valves—with Hycar rubber diaphragms—meet every requirement of speed and safety. Valves are located in the wing tanks. They are actuated automatically to stop fuel flow before tank capacity is reached. If the valve's rubber diaphragm were to fail under the terrific pressure, fuel would overflow . . . the fuel tank might rupture . . . the entire wing structure might be damaged. You can see the important part the Hycar rubber diaphragm has in successful refueling.

Hycar not only withstands extreme pressures, but also resists the deteriorating effects of aircraft fuel. It will not become brittle or crack with age. And Hycar also remains resilient and flexible through a temperature range required for this application of –65°F. to 167°F. The Hycar rubber is compounded to meet military specification MIL-R-6855, Class I.

Hycar rubber compounds have many advantages, are used in many industries. They resist heat and cold, abrasion, aging, gas, oil and many chemicals. They may help you improve or develop more saleable products. For information, please write Dept. HT-5, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

B. F. Goodrich Chemical Company
A Division of The B. F. Goodrich Company

Hycar
American Rubber

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers • HARMON colors

What's Screwy? by Phillips

"Don't let it worry you. Everything is made fast with Phillips Cross-Recessed-Head Screws."

PERFECTLY MATED! Only Phillips Drivers are perfectly mated to Phillips Screws. Look for the name Phillips on the shank.

VIBRATION RESISTANCE because of added structural strength is only one of the exclusive advantages gained by using Phillips Screws. These screws set up tighter and their distinctive design gives them maximum strength of head. And that's not all. Because they are unusually easy to drive, they cut driving time up to 50%, eliminate driver skids and split screw heads. You save time, work, money when you use Phillips Screws — Wood, Machine, Tapping Screws or "Sems."

PHILLIPS *Cross-Recessed-Head* SCREWS

X marks the spot... the mark of extra quality

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THE LAMSON & SESSIONS COMPANY • NATIONAL LOCK COMPANY
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PHEOLL MANUFACTURING CO. • ROCKFORD SCREW PRODUCTS CO. • SCOVILL MANUFACTURING CO.
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Eaton Permanent Mold Gray Iron Castings—

for HYDRAULIC CONTROLS

Send for your free copy of the 32-page illustrated booklet: "The Eaton Permanent Mold Foundry." It tells the story of Permanent Mold Castings and takes you on a picture-tour of the Eaton Foundry at Vassar, Michigan.

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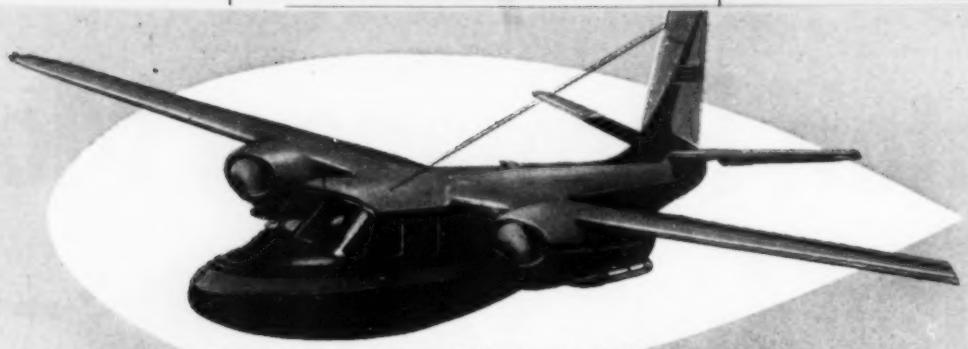
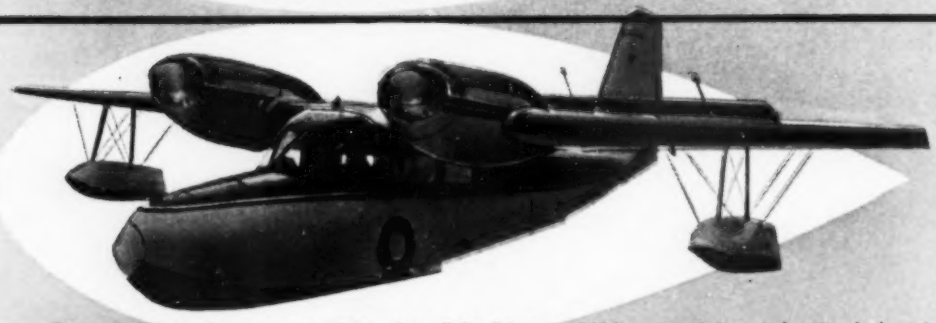
PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites® Spring Washers Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers



Aero-Commander. Seats 6. Powered by two 260-h.p. Lycoming air-cooled, geared engines.



Grumman Widgeon Conversion. Amphibious flying "office" featuring 260-h.p. air-cooled, geared engines by Lycoming.

Safest "offices" over earth

You are now looking at the "wings" carrying America into a great new era of safe, economical executive transportation. Each of these twin-engine, multi-passenger planes is powered by Lycoming . . . long a leader in the up-to-500-h.p. engine field. Each has the double dependability of *two* air-cooled Lycoming engines—so powerful that the planes can safely fly and land with a full load *on one engine alone.*

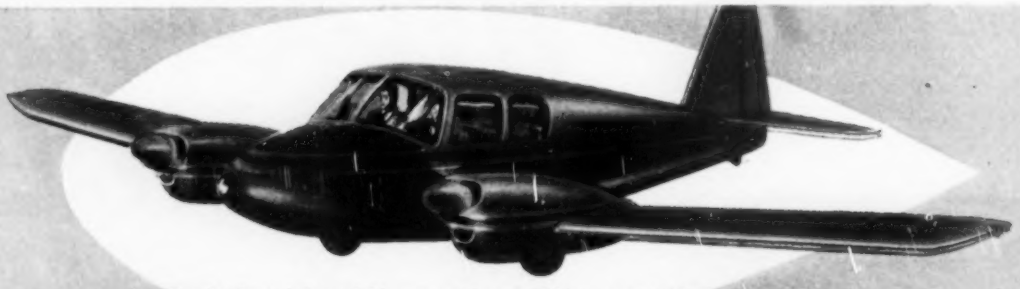
To fly any time, any place . . . these are the safest "offices" *over* earth . . . the soundest investments in executive aircraft *on* earth. *For further information, write us on your letterhead.*

FOR RESEARCH · FOR PRECISION PRODUCTION

LOOK TO **LYCOMING**

Lycoming-Spencer Division, Williamsport, Pa. AVCO Bridgeport-Lycoming Division, Stratford, Conn.

Air-Cooled Engines for Aircraft and Industrial Uses. Precision-and-Volume Machine Parts. Gray-Iron Castings. Steel-Plate Fabrication

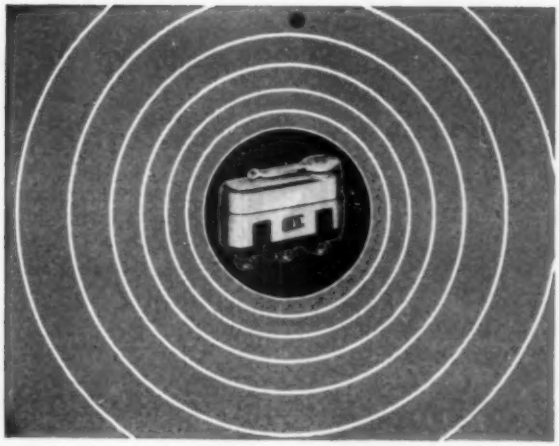


Piper Apache. Seats 4. Dependably powered by two 150-h.p. air-cooled Lycoming engines.

Riley Twin Navion Conversion. 4-place executive plane powered by two 150-h.p. air-cooled Lycoming engines.

Better Products Thru Better Design

how short cuts to tomorrow's new products develop from cooperation of designers and MICRO Switch field engineers today



TOMORROW will belong to those manufacturers who are actively striving today to design new products for new jobs —or to redesign products to do their jobs better.

Success in such new designs often hinges on the skillful selection of even the smallest component parts—components that can be counted on to perform their function day after day, so accurately and efficiently that their presence is almost forgotten.

Prior to MICRO's pioneer efforts in the precision switch field, many of today's successful designs would have been difficult or impossible. MICRO switches, from the first, have been a short cut to better products. The small size, light weight, precise action and absolute dependability of MICRO switches swept away many old design conceptions.

Through the use of MICRO switches in his product, more than one manufacturer has become a leader in his field. By including MICRO switches, many designers have added greater reliability, more precise action and longer life to products that meet new demands or fill present needs more acceptably.

Design problems which "stumped the experts" have been solved through the cooperation of industrial designers and MICRO field engineers. This cooperation has resulted in the development of a vast reservoir of precision switch types. It may easily provide your short cut to better design.

Let us tell you about a few recent developments:

—A hermetically sealed switch which has proved itself in government atomic plants. These switches are called upon to operate accurately and over a long-life period in liquids that are "hot" in more ways than one. As the development of atomic power for commercial use becomes more and more of a factor in industry, MICRO, already able to supply switches to meet such requirements, will be fully prepared.

* * * *

—A fast-action switch to meet the demands of a manufacturer of "overload relays." These relays operate thermally to stop a motor in case of overload. A special type of MICRO switch enabled him to produce his equipment in lighter weight and smaller size than was hitherto possible. The switch operates magnetically in case of a short circuit or quick overload and must be reset manually before operation can be resumed.

* * * *

—A small low-torque switch which has saved many thousands of dollars worth of electrical equipment. In such devices, the concentration of power in smaller and smaller space frequently requires a flow of air to cool equipment and prevent tube burnout. Many a manufacturer of electronic devices depends on this type of MICRO switch to shut off the power instantly in case the air stream is not moving.

* * * *

Meeting such varied problems of industry has resulted in over 6000 different types of MICRO switches, each contributing to "better products through better design."

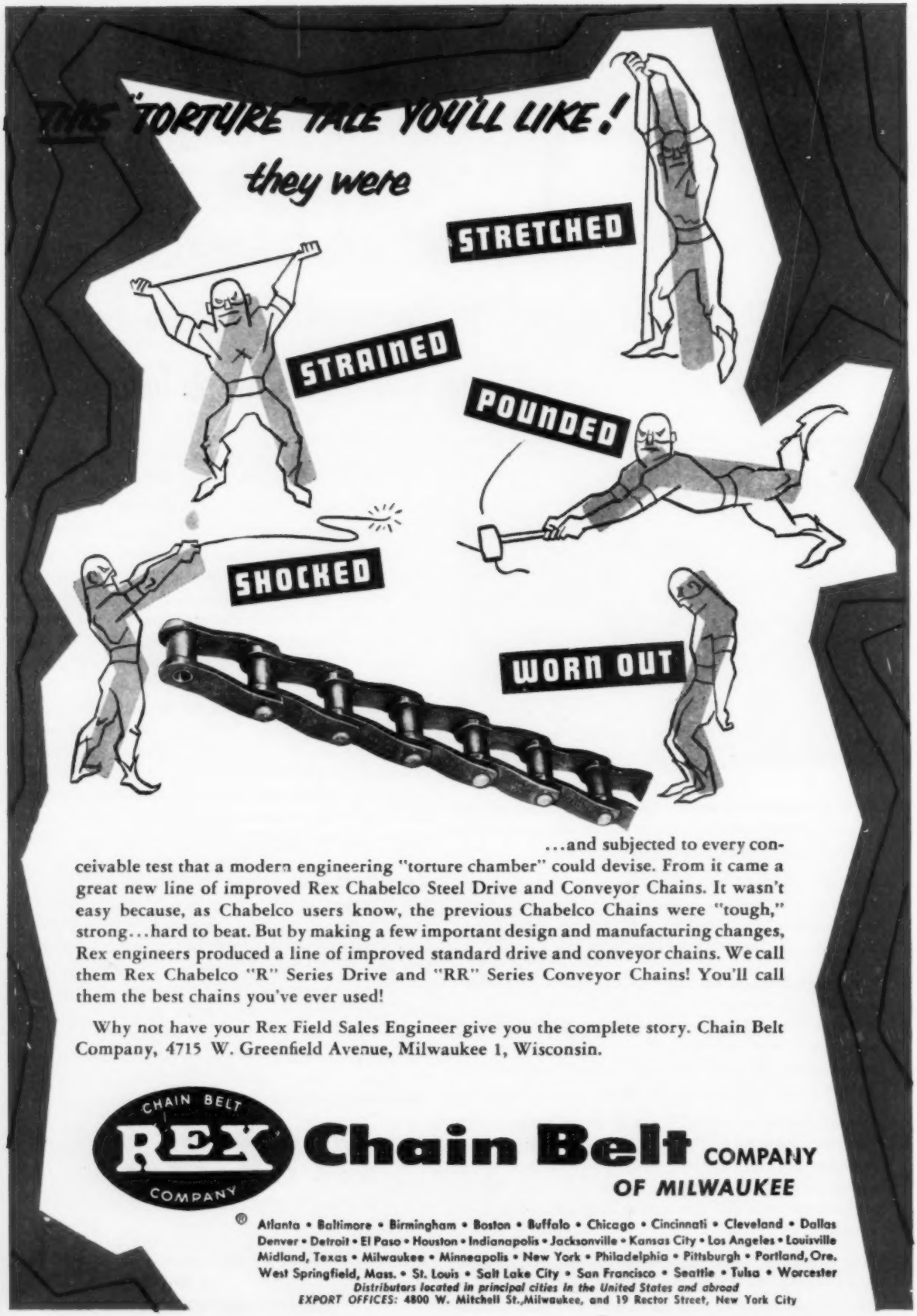
MICRO

MAKERS OF PRECISION SWITCHES

FREEPORT, ILLINOIS

A DIVISION OF

MINNEAPOLIS-HONEYWELL REGULATOR COMPANY



...and subjected to every conceivable test that a modern engineering "torture chamber" could devise. From it came a great new line of improved Rex Chabelco Steel Drive and Conveyor Chains. It wasn't easy because, as Chabelco users know, the previous Chabelco Chains were "tough," strong...hard to beat. But by making a few important design and manufacturing changes, Rex engineers produced a line of improved standard drive and conveyor chains. We call them Rex Chabelco "R" Series Drive and "RR" Series Conveyor Chains! You'll call them the best chains you've ever used!

Why not have your Rex Field Sales Engineer give you the complete story. Chain Belt Company, 4715 W. Greenfield Avenue, Milwaukee 1, Wisconsin.

CHAIN BELT REX COMPANY

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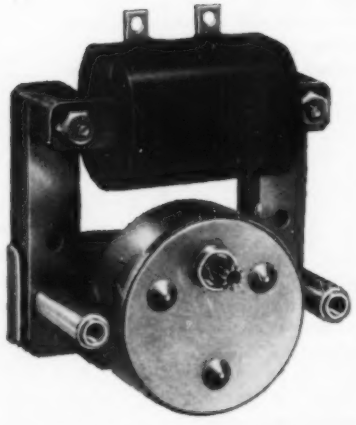
FILLING STATION

...FOR LONG-LIFE LUBRICATION

Telechron Synchronous Timing Motors



MODEL H-10. *Low-cost, light-duty motor capable of handling high momentary peak loads. Ideal for washing machines, dishwashers, refrigerators, and other appliance timer uses.*

Seal the oil in with the moving parts, and they'll both last longer. That's the simple reason behind the long, dependable life of Telechron Synchronous Timing Motors.

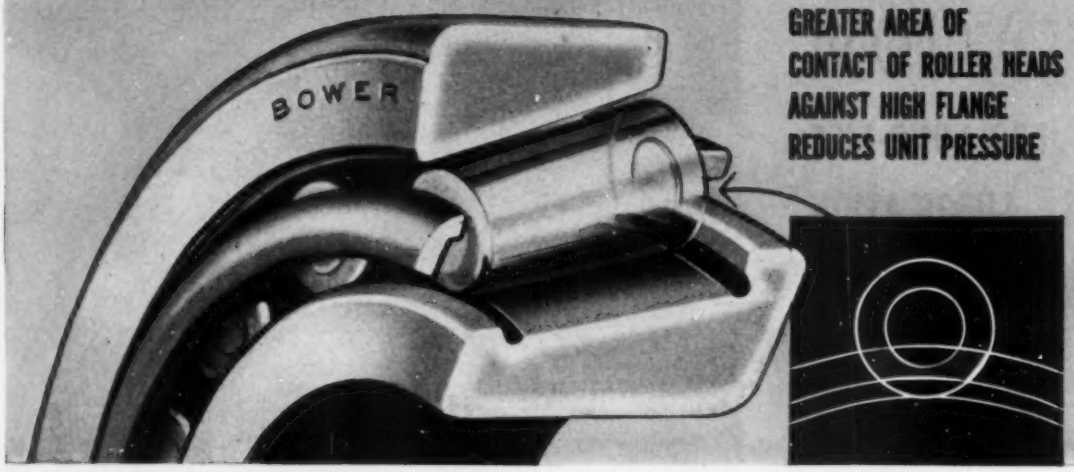
Into each motor goes a measured amount of special oil—carefully formulated for the particular service the motor is to perform. Then the unit is sealed. Dirt and dust can't get in. Lubricant is lifted by capillary action from the reservoir to all bearings, and flows continuously to all gears, efficiently . . . so efficiently, in fact, that many Telechron motors are still operating accurately and dependably after 20 years of continuous use.

There are other advantages, too, in Telechron Synchronous Timing Motors. Quick starting, due to the lightweight rotor. Power-line accuracy, because of true synchronous operation. Cool running, with the field coil isolated from the rotor unit. Altogether, a combination of worth-while features unique in the field of electric timing.

Telechron motors are available in a wide range of speeds and torque ratings, and for any standard AC power source. Get full details. Write Telechron Department, General Electric Co., 19 Homer Ave., Ashland, Mass.

Telechron®
MARK OF TIMING LEADERSHIP

Bower spher-o-honed design increases bearing life



Bower engineers have incorporated many basic refinements into the design of Bower tapered roller bearings which cut maintenance to a bare minimum—increase efficiency. One of the most important of these is the *exclusive* feature illustrated above. Note that the flange at the large end of the cone is *higher*—providing a greater contact area for the roller heads. This greatly reduces wear, improves roller alignment and minimizes resultant "end play". Also note the larger oil groove, providing positive lubrication to the roller heads.

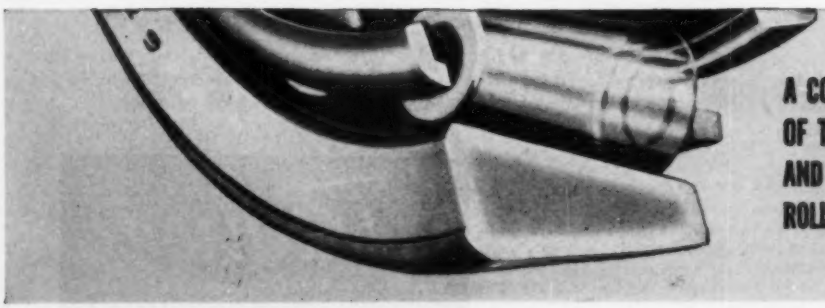
Other important Bower features which increase bearing life and dependability are generated spherical rollheads, and smooth, precision-honed races. And Bower bearings are known throughout industry for materials and workmanship of highest quality.

Whether your product is in full production or still in the planning stage, you'll be wise to call in a Bower engineer now. He'll show you a wide range of sizes and types to fit any application.

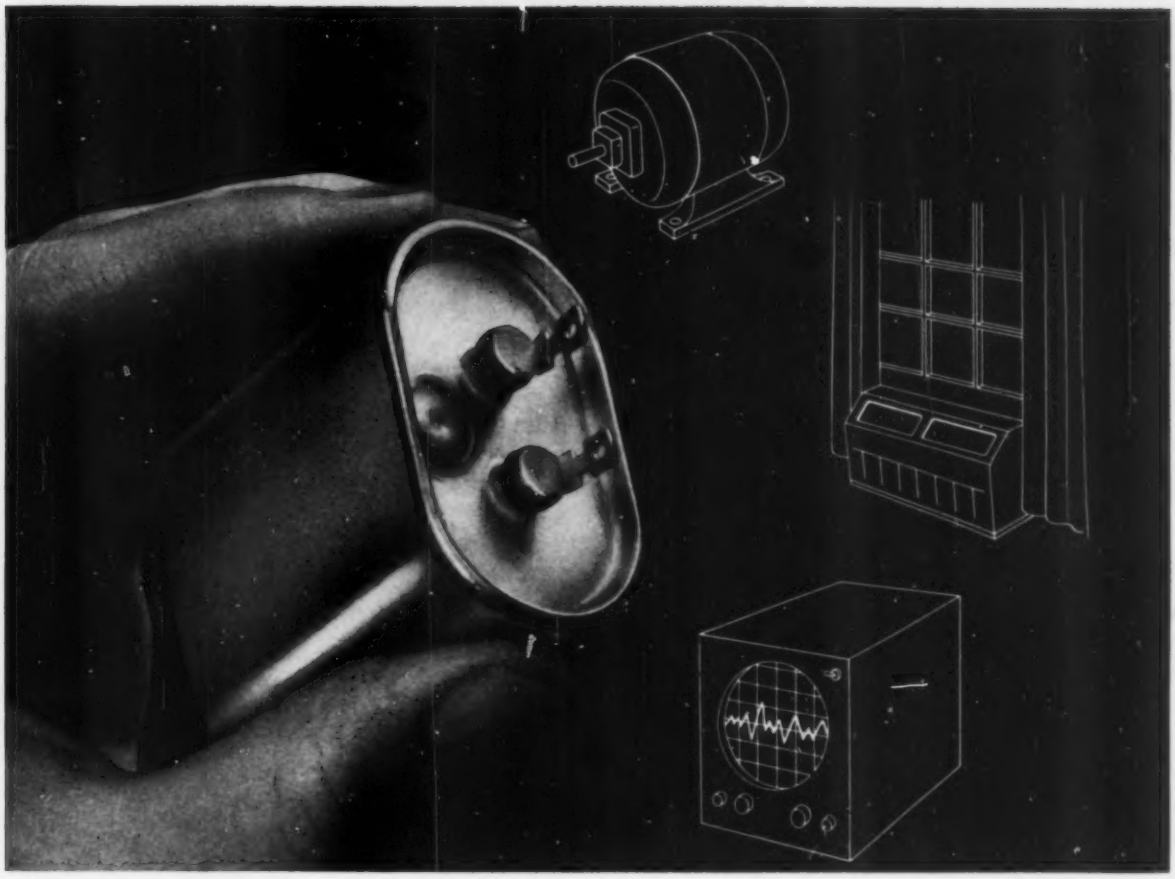
BOWER ROLLER BEARING COMPANY • DETROIT 14, MICHIGAN

BOWER
ROLLER BEARINGS

SPHER-O-HONED



A COMPLETE LINE
OF TAPERED, STRAIGHT
AND JOURNAL
ROLLER BEARINGS



New oval-shaped General Electric capacitor saves space and weight in your electric equipment

If you're using fixed paper dielectric capacitors in case styles CP 53 and CP 70 it will pay you to consider General Electric drawn-oval units. These drawn-oval capacitors provide unsurpassed reliability combined with the important advantages of permitting smaller size, less weight and lower cost in the electric equipment you manufacture.

RATINGS range from 1 to 10 .muf, 600 to 1500 volts dc, or 330 to 660 volts ac. Choice of mounting arrangements makes them ideally suited for air-conditioning units, electronic equipment, motors and controls or other applications where units capable of meeting all electrical and mechanical requirements of MIL-C-25A specs, except for case dimensions and markings, are desirable.

DOUBLE-ROLLED SEAM attaches cover to drawn-steel case—producing a lighter, yet stronger capacitor. Actual savings in size and weight vary with case style and rating but can amount to as much as 30%. Depending upon case style and quantity ordered, prices average 10 to 20% lower than for rectangular capacitors.

MOUNTING VERSATILITY is provided by choice of three bracket styles for upright, inverted and side mounting to suit individual mounting requirements.

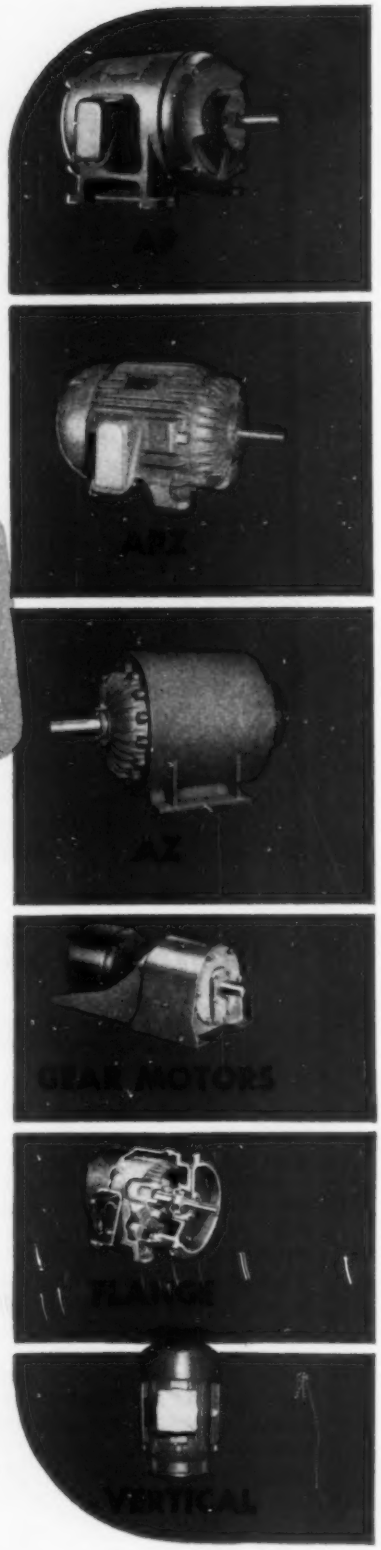
For more information on the new G-E drawn-oval capacitors, their ratings, dimensions and prices, contact your local G-E apparatus sales representative or write for Bulletin GEA-5777, General Electric Co., Section 442-10, Schenectady 5, N. Y.

1878 75 1953 YEARS OF ELECTRICAL PROGRESS

You can put your confidence in—

GENERAL ELECTRIC

Find the Answer to Your Motor Problems Here ⇨



ALLIS-CHALMERS Motors for Designers

ON THIS CHART YOU WILL FIND a standard type Allis-Chalmers motor to fit nearly every design need from ½ hp up. Many of them have exclusive construction features, such as fin cooling and tube cooling, which offer you premium performance without premium price. Many times these features will enable you to improve your design without adding to the cost of the machine.

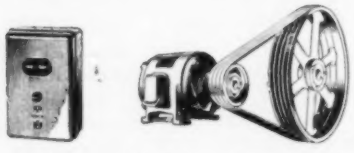
And, of course, modifications from strictly standard designs can easily be made to fit your particular requirements.

FREE HELP FROM EXPERIENCED DESIGN ENGINEERS

If you have a special problem, Allis-Chalmers will gladly furnish experienced design engineers to help you work out your motor problems. Allis-Chalmers design engineers are particularly helpful because A-C's strong background in control, drives and many types of driven machines gives them an especially intimate knowledge of motor requirements.

When you have a design problem involving motors — or any part of the machine from power line to driven shaft — call your nearby Allis-Chalmers District Office. In the meantime, send the coupon below for a complete booklet of motor types and characteristics. Ask for Bulletin 51B6052M.

One Source for Complete Drive Unit



Control Motor Texrope Drive

Engineered and built to work together. Your Allis-Chalmers District Office Representative can supply you with a complete, coordinated drive. You save selection time and are sure of dependable operation.

Texrope is an Allis-Chalmers trademark.

SEND COUPON FOR FREE LITERATURE AND SELECTION CHARTS

Allis-Chalmers Manufacturing Company
Box 512, Milwaukee 1, Wisconsin

Please send me the following free literature to help me solve my design problems.

- ☐ Handy Guide to Electric Motors (51B6052)
- ☐ Handy Guide to Texrope Drives (20B6051)
- ☐ Across the Line Starters (14B7132)

Name .....

Company .....

Position .....

Address .....

City ..... State .....

A-3575

ALLIS-

RANGE
½ to 150 hp. 450 to 3600 rpm. 208, 220, 440, 550 volts. Frames 204 to 445 in AP construction. 504 and 505 in AW construction.

CONSTRUCTION
Stator yokes for AP motors are cast iron and have no bottom openings. AW motors are built with cast steel yoke heads, with integral mounting feet, and heavy continuous-welded steel drip covers. Stator slots are semi-closed for the smaller sizes, open type with form-wound coils for the larger sizes. Windings are multiple dipped and baked. Rotors are cast aluminum with integral fans in frames 405 and smaller. Copper or copper alloy is used for larger ratings. Bearing end shields are cast iron. Ball bearings are available in all sizes. Sleeve bearings in some larger sizes.

MODIFICATIONS
Basic motor is open drip-proof rated 40°C continuous, NEMA Design B. Design C and D motors also are standard while Design A motors are considered special. Other electrical modifications available include 110 volts on frames 326 and smaller and 2300 volts on frames 445 and larger, and multi-speed motors with constant torque, variable torque and constant horsepower. Mechanical modifications include splash-proof rated 50°C continuous. Other modifications, both mechanical and electrical, can be made to suit your specific requirements.

RANGE
½ to 100 hp. 600 to 3600 rpm. 208, 220, 440, 550 volts. Frames 203 to 254 in non-ventilated construction. Frames 254 to 505 TEFC construction.

CONSTRUCTION
Special non-clogging design blows itself clean, is easy to wipe or blow off if oily or moist dirt sticks.

Fan-cooled and non-ventilated types have the same construction except that the fan-cooled motors have an external fan and fan shield to circulate and direct air over the motor enclosure. Stator yoke is ribbed cast iron, designed for easy cleaning. Stator winding is the same as in open types. Bearing end shields are ribbed cast iron. Ball bearings are used except for 75 and 100 hp, 3600 rpm motors, which have split sleeve bearing construction.

Explosion-proof motors have extra deep rabbeted housing fits and bearing seals. All seals are metal to metal.

MODIFICATIONS
Basic motor is totally-enclosed, fan-cooled rated 55°C continuous, NEMA Design B. Design C and D motors also are standard while Design A motors are special. Same electrical modifications are available as in open types. Mechanical modifications include non-ventilated in smaller sizes and explosion-proof, both ventilated and non-ventilated, approved by Underwriters for Class I, Group D and Class II, Group F and G hazards.

RANGE
40 to 2500 hp. 600 to 3600 rpm. 208, 220, 440, 550 volts plus higher voltage in larger sizes.

CONSTRUCTION
Ventilating system is simple but highly efficient. The stator core is surrounded by a nest of tubes. Internal fans circulate the inside air around the tubes, while an external fan drives outside air through tubes to dissipate the heat. This arrangement permits full internal air circulation. Cleaning is easy but seldom necessary. Stator yoke is heavy fabricated steel construction. Cooling tubes are generally copper but may be of other materials. Rotor construction is determined by speed, rating, and application. Bearing end shields are heavy cast iron, with internal and external ribs. Ball bearings are used except 3600 rpm, which have sleeve bearings. Explosion-proof motors differ from standard enclosed machines only in details.

MODIFICATIONS
Basic motor is totally-enclosed, fan-cooled rated 55°C continuous, NEMA Design B. Design D and C motors also are standard while Design A motors are considered special. Same electrical modifications are available as in open types. Mechanical modifications include explosion-proof construction in all sizes approved by Underwriters for Class I, Group D and Class II, Group F and G hazards. Cooling tubes may be made of any material to withstand corrosive action of refinery vapors, fly ash, and other air-borne corrosives. This motor also available in vertical mounting type in all sizes.

RANGE
7.5 to 520 rpm with 1750 rpm motors. 1 to 50 hp. 208, 220, 440, 550 volts. Horizontal or vertical types.

CONSTRUCTION
Integral type uses round frame, D-flange motor, resulting in shorter overall length. All-motor type uses standard foot-mounted motor—recommended whenever space permits. AGMA Class I, II, III gears for steady loads, moderate shock loads, and heavy shock loads respectively. Gears have compact, rigid, all steel housings. Large shafts, husky bearings and strong bearing mountings resist severe loading. Heat treated alloy steel helical gears are lubricated by direct dip for safe continuous lubrication, protected by heavy duty shaft seals.

MODIFICATIONS
Any standard motor may be used with the complete range of mechanical and electrical modifications shown above. In addition, special designs can be built to meet special problems.

RANGE
½ to 150 hp. 450 to 3600 rpm. 208, 220, 440, 550 volts. Frames 203 to 505 in all constructions.

CONSTRUCTION
NEMA C face and D flange mounting construction is available in frames 505 and smaller in the same range of rating as the AP and AW types of motors shown at left, including mechanical modifications such as splash-proof and enclosed construction. Construction features and electrical modifications available are also the same as for the standard motors.

MODIFICATIONS
Flange motors may be supplied with or without feet, as required. Round frame motors without feet include a special ventilating fan to supplement the regular rotor fans. The mounting face or flange may be obtained especially machined to fit specific applications at moderate additional cost. Motors may be mounted horizontally, vertically (except in certain cases) or at an angle.

RANGE
½ hp and up. 450 to 3600 rpm. 208, 220, 440, 550, 2300 and higher voltages. Frames 203 to 505 and up.

CONSTRUCTION
Vertical motors with NEMA type P bases are available in the same range of ratings as the AP, AW, and AZ types shown at left, including mechanical modifications such as totally-enclosed and explosion-proof construction. Construction features and electrical modifications are same as for standard horizontal motors.

MODIFICATIONS
Ball bearings are interchangeable with those of horizontal motors. Special bearings for additional thrust carrying capacity are available in some cases. Where required special lubricating and grease retaining features are available.

CHALMERS AC

NATIONAL OIL SEAL LOGBOOK

Write our Redwood City office for reprints of this Logbook page

Sealing News & Tips

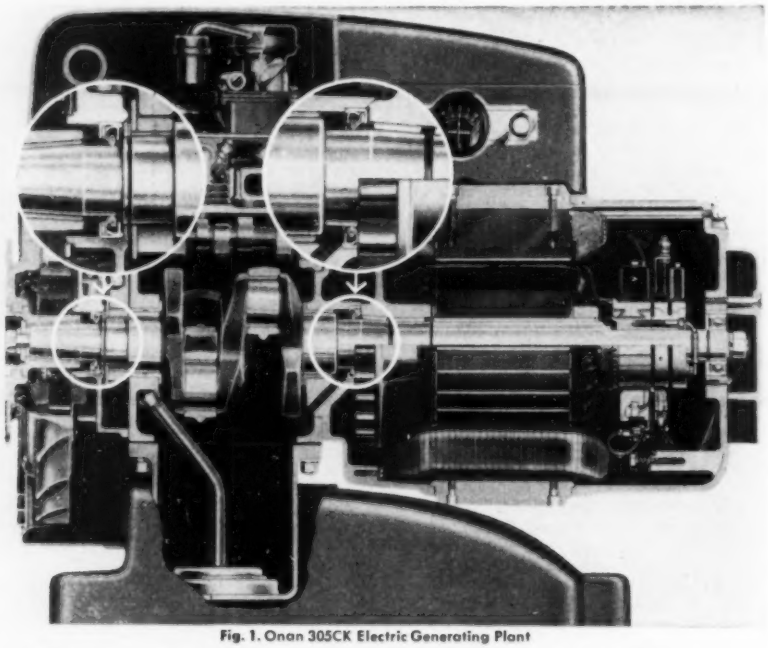


Fig. 1. Onan 305CK Electric Generating Plant

"Zero leakage" crankshaft sealing in Onan two-cylinder generator engine

The four-cycle "CK" gasoline engine used in Onan generator sets employs two pistons which move in and out at the same time. This creates a pulsating pressure in the crankcase which together with a speed range of 600 to 3,500 R.P.M. and an oil temperature range of –25° to 240° F. results in a serious crankshaft sealing problem. Zero leakage is mandatory because of the flywheel magneto and electric generator at either end of the shaft.

Onan engineers found that ordinary seals that were tight enough to retain oil absorbed too much engine horsepower, heated up, cracked and leaked. The oil leak rejection rate in the Onan test room averaged 15%.

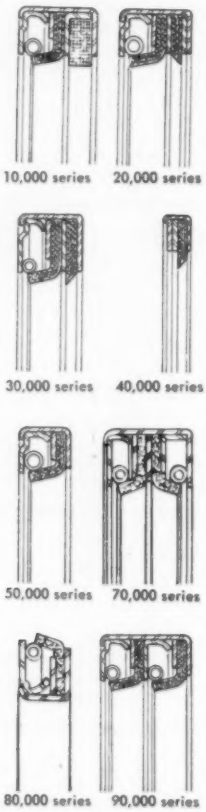
Installation of modified National 50,000-S Syntech* (synthetic rubber) seals (Figure 2) returned maximum horsepower to useful load, eliminated hardening and cracking, cut test room rejections to .05% and performed satisfactorily even after 5,000 hours. Seals used were conventional National designs with precision molded, trimmed and bonded Syntech sealing members. These seals have a low-friction sealing lip, accurately spring-tensioned.

Fig. 2. National 50,000-S Syntech Seal

National Applications Engineers can apply one of 2,500 standard-design National Oil Seals to your problem, or design special seals for special conditions. Call or write the nearest National office for information and engineering assistance.

*T.M. Reg.

Standard-design National Oil Seals are available in many types, sizes and shapes for almost all applications. Here are just a few basic designs incorporating leather sealing members. Similar designs are available in synthetic rubber.



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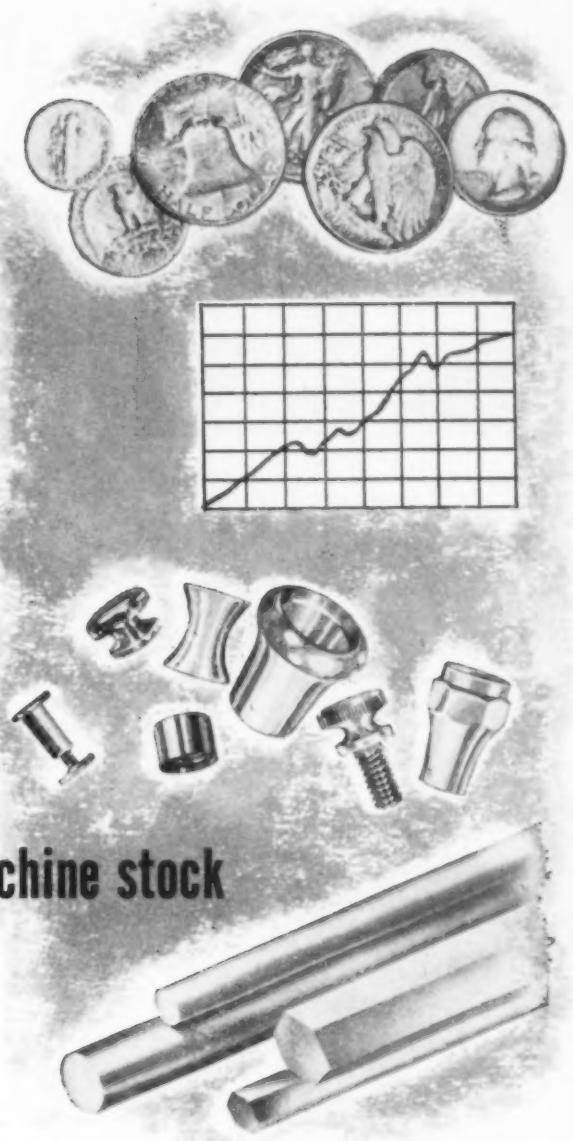

Lower your costs by saving on aluminum's big price advantage over other non-ferrous metals. Get more machined pieces per pound because of aluminum's lighter weight—⅓ that of brass or steel. Save on the high market value of aluminum scrap.

Raise your production with Kaiser Aluminum alloys that are free machining and that can be cut at high speeds and feeds, especially on larger size parts.

Improve your product by taking advantage of aluminum's unique combination of advantages, which include lightness, strength, corrosion resistance, heat and electrical conductivity, heat and light reflectivity and beauty.

Important suggestion for product designers! Be sure to request an alternate bid in aluminum with each bid you request in another material. This is the easy and logical way to compare both price and suitability of the materials. You'll find that aluminum usually will greatly reduce your per-piece cost and can give you a better part at the same time.

Call in a Kaiser Aluminum engineer. He'll gladly give experienced assistance with alloy selection, design considerations, production techniques. Prompt deliveries of round and hexagonal Kaiser Aluminum screw machine stock now being made by us and our distributors. Look under "Aluminum" for our local telephone number. Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, Calif.

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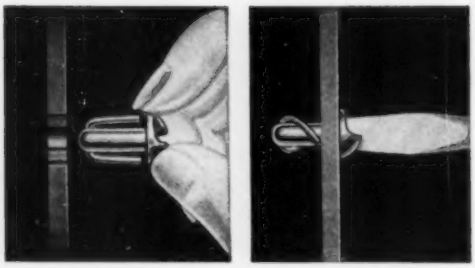
Have you a similar use for this 1-piece fastener?



It's a Blind Rivet

...Or a removable fastener. It locks and unlocks with a 90° clockwise rotation. No mating parts such as nuts or receptacles are required.

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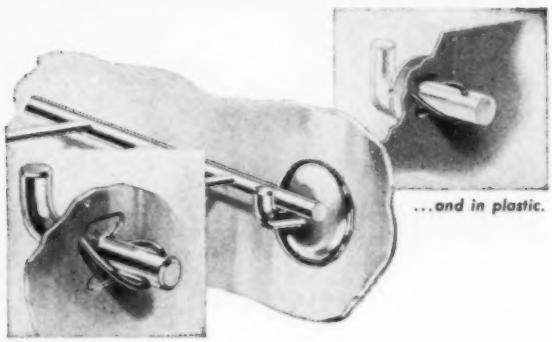
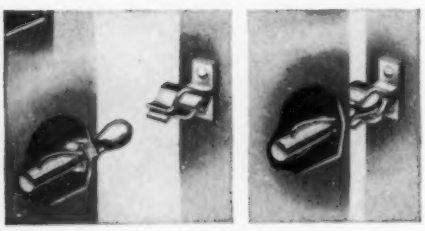


...and in plastic.

Both in metal...



It's a Cabinet Door Strike

...Simple to install; eliminates welding and cuts assembly cost. Any head can be designed without affecting fastening principle.

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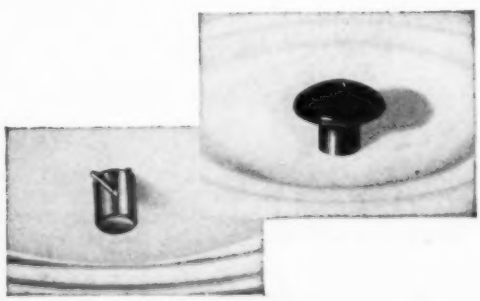
...Plastic Spring-Lock heads are molded around steel inserts, giving strength at point of load or impact. Any shape head can be molded in any color.



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...Tell us how you can use Spring-Lock Fasteners in your products. We'll be glad to work out the details with you.

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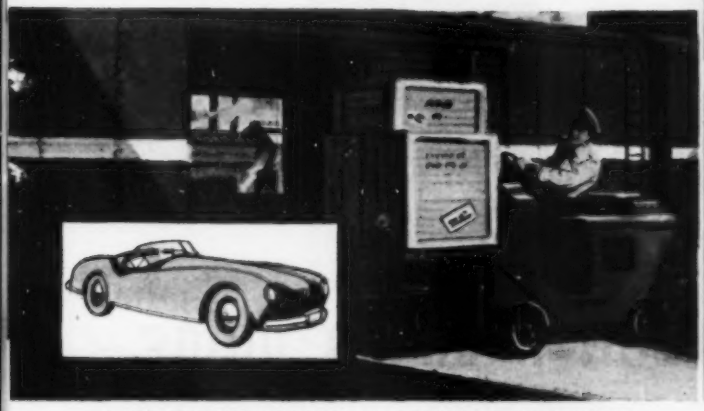

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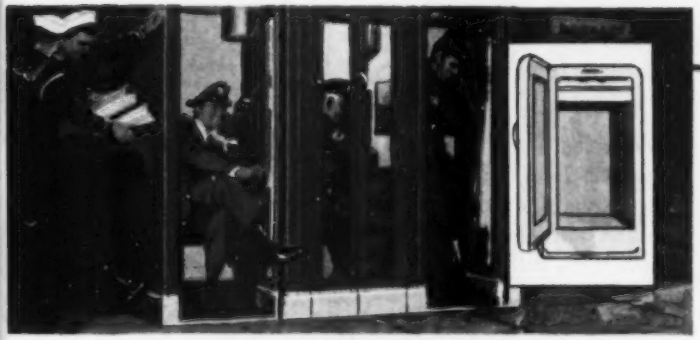

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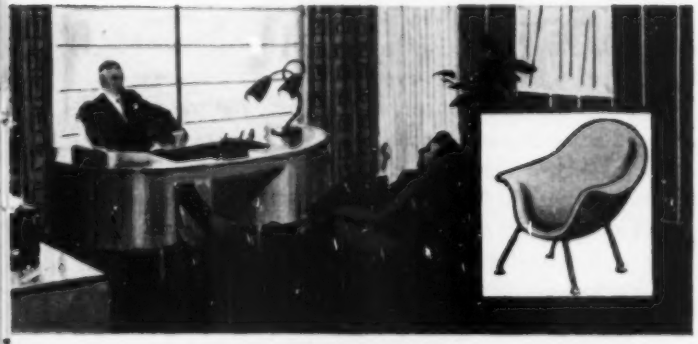

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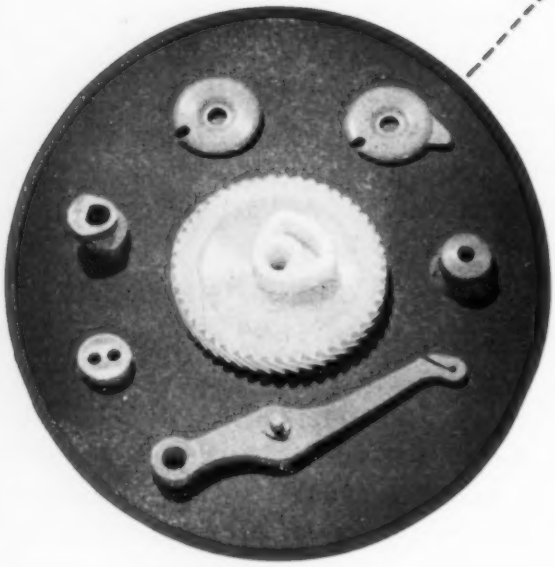
Parts of DU PONT NYLON need no oiling



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In designing a new, lightweight portable sewing machine, the Bell Manufacturing Corporation specified that the machine's key parts—gears, cams, arms, links, nuts and discs—be molded of Du Pont nylon. After extensive tests, Bell found in Du Pont nylon an engineering material that provides improved performance of these parts at low cost.

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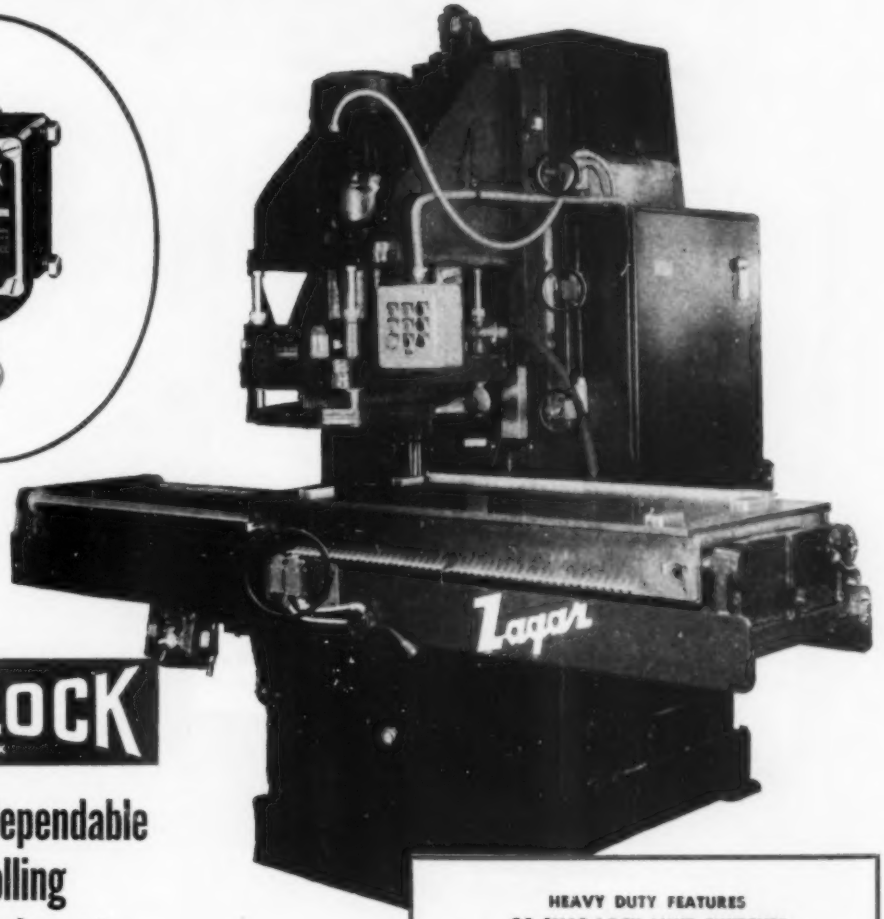
Molded Du Pont nylon today is contributing to many design and operating improvements. Perhaps its unique combination of mechanical, electrical and other properties can help you improve or develop a product. For further information, write: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 109, Du Pont Bldg., Wilmington 98, Delaware.

for jobs where you "can't take chances"...



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This Zagar acoustical wall tile drilling machine employs 5 Snap-Lock limit switches—three automatically controlling movements of the 96 spindle drill head and two actuating the hydraulic system operating the work table.

Zagar Tool Inc., Cleveland, O., manufactures drill heads, drilling and broaching machines. After 10 years experience with Namco Snap-Lock limit switches applied to a wide variety of large and small machine tools, Mr. Frank Zagar, General Manager states—

> **"for the fast, exacting and dependable controls in our machines, we can take no chances—we recommend Snap-Locks to customers all over the country"**

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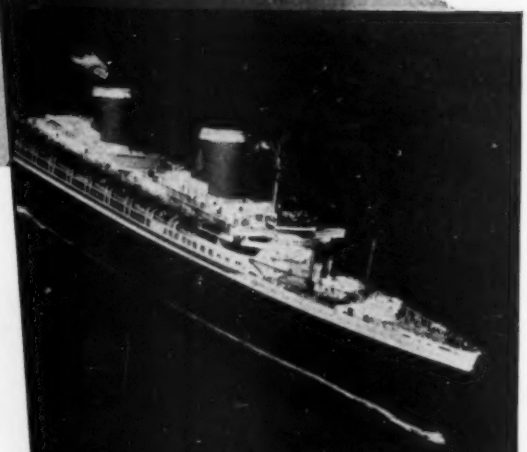

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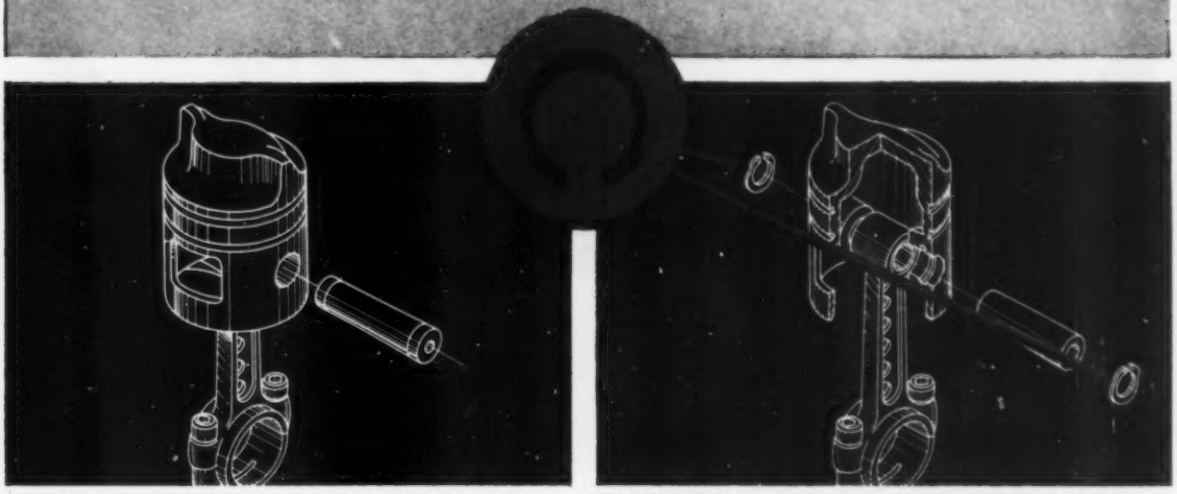
2 Waldes Truarc Rings Replace 2 End Plugs ...Eliminate 3 Operations...Save $.066 Per Unit



OLD WAY Two inserted-plug type wrist pin locks hold wrist pin in place. 3 operations involved: costly machining, pressing in place, post-assembly machining. Costly maintenance problem—resulting from end plugs hammering loose.

TRUARC WAY Two Truarc Inverted Retaining Rings (Series 5008) hold wrist pin in place. Truarc Rings snap into grooves easily cut in piston, provide positive lock . . . practically eliminate maintenance costs. Quick assembly, disassembly.

Titan Chain Saws, Inc., Seattle, Washington, uses 2 Waldes Truarc Rings to replace old-style inserted-plug type wrist pin locks in their Titan chain saws. Use of Waldes Truarc Retaining Rings eliminates 2 press fit end plugs. Machining of plugs, pressing in place, finish machining—no longer required. Truarc way holds rejections to a minimum. Unit efficiency is greatly increased.

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Cost of grooving piston Cost of 2 Truarc Rings	.103
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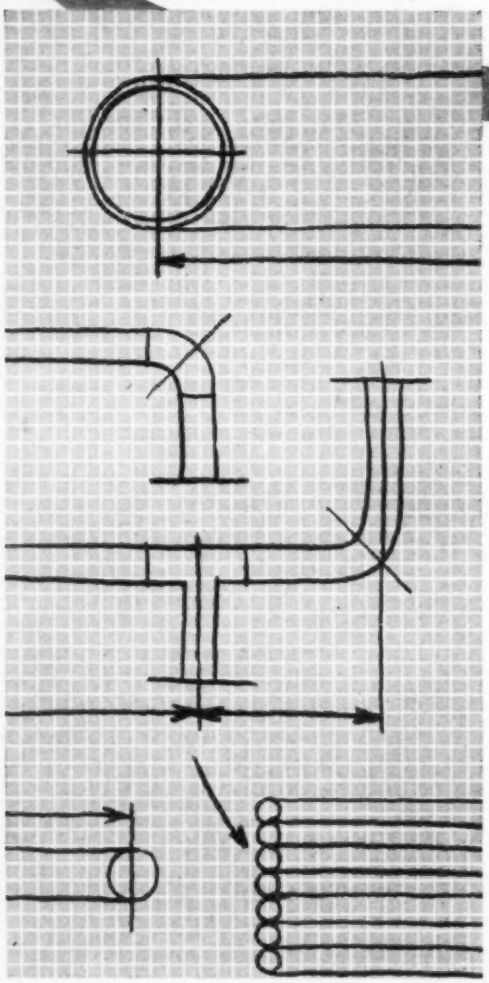
How to Design for Customer Satisfaction



The people who buy your products may look for many things such as efficiency, long life and eye appeal. Specifying Stainless for tubular parts may give them what they want.

But specifying Carpenter Stainless gives them more of it—and makes your production men happier, too. Helps step up your plant efficiency and profits.

Here's why. Carpenter Stainless is *different* . . . has many "extras" in working properties, corrosion resistance, tolerances, finishes . . . and we'd like to prove it to you.

One way we can do so is to ask you to call your nearest Carpenter distributor for documentary evidence. But you'll get quicker and more conclusive proof if you place your next tubing order with him. You'll discover that there *is* a difference in Stainless Tubing—and Carpenter makes it.

The Carpenter Steel Company, Alloy Tube Division, Union, N.J.
Export Dept.: The Carpenter Steel Co., Port Washington, N.Y.
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Carpenter

STAINLESS TUBING & PIPE

Analysis → Tolerance → Finish →

• guaranteed on every shipment

it pays up to 50% to think

FIRST

about last operations

Parker-Kalon Self-tapping Screws have been cutting assembly costs of millions of metal and plastic products for over 35 years. Yet, today, thousands of manufacturers, who could gain the same benefits, still use such slow-down fastening methods as machine screws in tapped holes, bolting, and riveting. Why?

The reason is that too many product engineers think *last* about assembly because it is a final operation, then follow habit or custom in specifying fasteners.

Best way to make sure of savings you have been missing is to think *first* about fastenings . . . compare methods for simplicity, speed and security. Records show that in 7 out of 10 cases, P-K Self-tapping Screws show substantial savings, often up to 50% and more.

A P-K Assembly Engineer will help you get the facts you need. He'll call at your request. Parker-Kalon Corporation, 200 Varick Street, New York 14.

P-K Type A
—the FIRST Self-tapping Screw

The INDUSTRIAL DISTRIBUTOR steers your Supply Dollars to the best values.

PARKER-KALON®

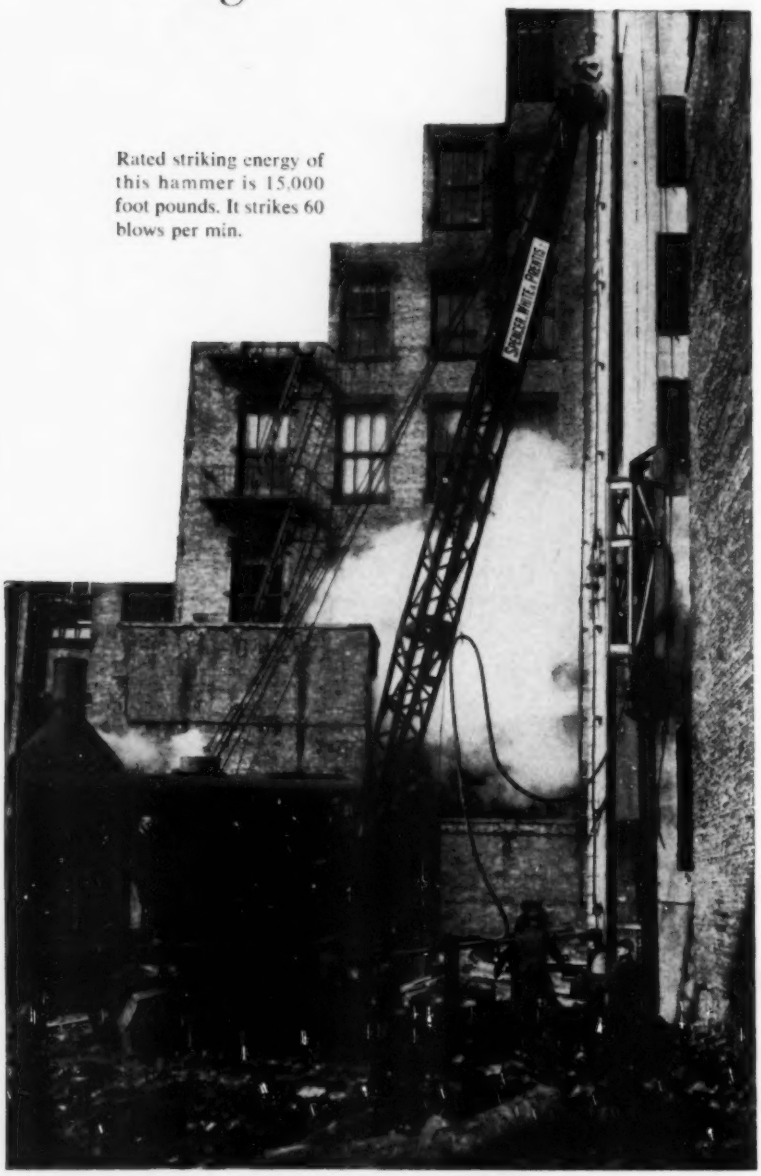
The Original **SELF-TAPPING SCREWS**

GET THIS GUIDE TO LOWER ASSEMBLY COST

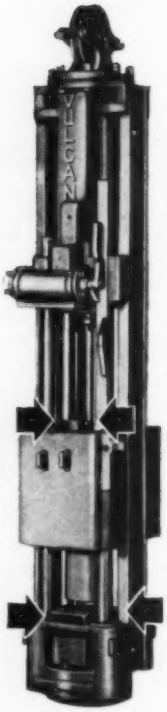
Filled with facts you need to plan for lowest cost when you plan assemblies. Ask your P-K Distributor, or write Parker-Kalon for Form 475-D.

This mark △ on every P-K Self-tapping Screw identifies it as genuine.

"U. S." cushions a pile hammer ...using a 53-year-old design



Rated striking energy of this hammer is 15,000 foot pounds. It strikes 60 blows per min.



Arrows indicate the "U. S." rubber bumpers. Despite the terrific series of impacts, they retain their natural resilience.

This pile hammer is equipped with 2 "U. S." rubber bumpers at the top of the ram, and 2 at the base. It's their job to absorb the smashing over-drive of the hammer and prolong the life of the equipment. But the main point is that for the last *53 years these bumpers have been built according to the same blueprint*. So perfect was the design that the makers of the hammer have never required any change.

This is an example of the quality built into every United States Rubber Company product. "U. S." engineers stand ready to work with you in the improvement of any product. Consult them at any of our 25 District Sales Offices. Or write to address below.

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Another "U. S." leader that has rolled up enviable records for long service is Matchless® High Pressure Steam and Pile Driver Hose. It is burst-proof, for the protection of the worker.

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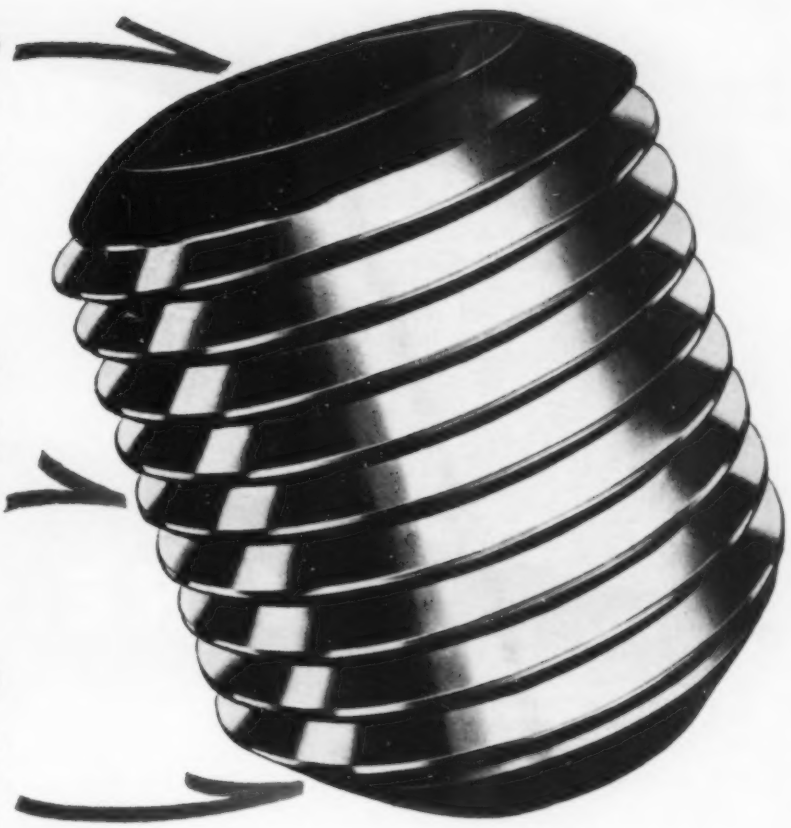
and see why the P-K Hex is the Standard for accuracy. It's true-centered, true to size, right depth for easy keying!*

Look here

for P-K *Ground Threads*, the smoothest, brightest, gage-like threads you've ever seen on a Socket Set Screw!*

Look here

for clean, burr-free starting threads, another advantage of P-K thread-grinding that means faster assembly!*



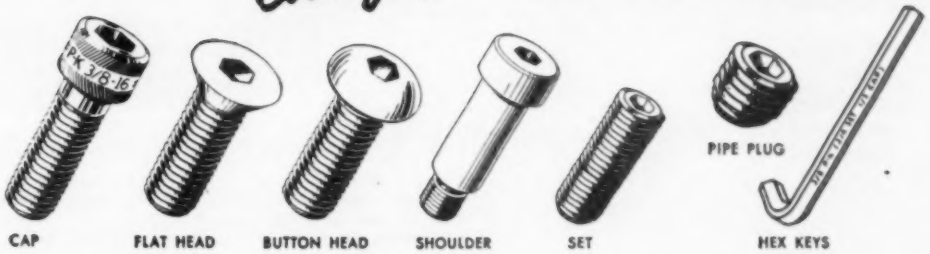
* You'll have to *look beyond* even the best picture to see the super-smooth, gleaming finish, the years-ahead quality of P-K Ground Thread Socket Set Screws. But you'll agree when you see the actual screws.

So get SAMPLES . . . and compare. Ask your P-K Distributor, or write Parker-Kalon Corporation, 200 Varick St., New York 14.

The INDUSTRIAL DISTRIBUTOR steers your Supply Dollars to the best values.

PARKER-KALON®

Cold-forged **SOCKET SCREWS**



NEW COPPERPLY* WIRE CLOTH

of

STEEL WIRE COPPER-COATED *Electrolytically*

Seldom has there been developed a wire cloth so desirable and so usable, for so many needs, and for so many products.

It's the *new* Reynolds *Copperply*. Woven of steel-core wire, coated with copper *electrolytically* applied — its perfect concentric coating may be of any thickness desired.

"Handsome is" in appearance, with its richly red copper color. "Handsome does" in performance, with its strength of steel, combined with copper's advantages. Non-rusting and enduring...corrosion resistant... high in electrical conductivity . . . dissipates heat quickly. And *Copperply* may be readily welded, soldered, or brazed.

Name the weave, mesh, and wire size... the exact gauge of steel wire core, and thickness of copper you want—and you can have it—in *Copperply* wire cloth.

Rely on Reynolds over-50-years experience for technical help in your production and product development. Consultation without obligation, of course.

* Trade Mark, National Standard Company.

Reynolds WIRE CLOTH protects performance

NS NATIONAL-STANDARD Company NILES MICHIGAN

REYNOLDS WIRE DIVISION, NATIONAL-STANDARD CO., **DIXON, ILLINOIS**

Divisions of National-Standard Co.

ATHENIA STEEL—*Clifton, N. J.*	Flat, High Carbon, Cold Rolled Spring Steel
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WAGNER LITHO MACHINERY—*Jersey City, N. J.*	Metal Decorating Equipment
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You'll be far ahead of the field with

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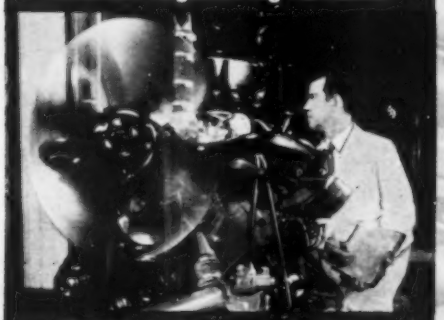
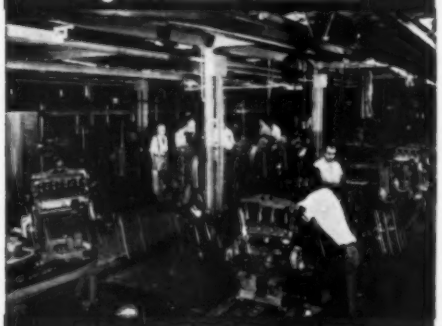
Constant Engineering Advances



Matchless Research Facilities

High-Precision Standards



Mass Production Savings

Always at your Service

Experienced Ford Sales Engineers will gladly prepare recommendations for the efficient use of Ford Industrial Power in your application.

YOUR JOB IS WELL-POWERED WHEN IT'S FORD-POWERED!

Here's why—

These are hard-fisted facts that equipment manufacturers and users should know about!

As these pictures portray, the engineering and manufacturing facilities of the Ford Motor Company are unmatched in the field of Industrial Power. This has resulted in advanced features of engine design that are years ahead of the industrial field.

Let us mention just a few for example: Ford offers a choice of six engines varying in displacement from 134 cu. in. to 317 cu. in. in the popular range. Of these, four are latest design overhead valve, short stroke, low-friction, high-compression type, that deliver more actual power at the clutch than was formerly possible in any engines of comparable size. Features include precision-molded, fully counter-balanced crankshafts; full-flow oil filters; free-type, self-rotating valves; rigid, deep-skirt crankcase and many others. These advancements mean longer engine life and lower operating cost.

Every Ford Industrial Engine or Power Unit is a complete assembly, fitted with a long list of standard equipment *at no extra cost.* All are *thoroughly tested* before shipment and are *ready-to-run!* In a word or two, Ford Industrial Power provides unexcelled efficiency . . . not only more power per pound, but more power per cubic inch displacement at low piston speed.

We will be happy to send you descriptive folders with complete information. Why not write or . . . if necessary . . . wire us today?

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INDUSTRIAL ENGINES AND POWER UNITS

The answer to any bearing problem...

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. . . because you'll find all the right answers in a Hyatt catalog. Hyatt's complete line of cylindrical roller bearings—more than 800 sizes in the Hy-Load series alone—makes your job easier, because it makes possible greater design flexibility. And in addition, when you specify Hyatt bearings you know you're getting the very best! If your file of Hyatt catalogs is incomplete, contact one of Hyatt's sales-engineers—or write to Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

ALCOA SECTION
Page 1 of 8 Pages

NEW KENSINGTON, PA.

Designers today use hydraulic extrusion as a less expensive and more effective means of producing many shapes once rolled or machined. This is reflected in over-all extruded shape production which increased from 100,000,000 pounds in 1949 to over 250,000,000 pounds in 1952.

Biggest non-defense user, the building industry, last year used extruded shapes at the rate of 10,000,000 pounds monthly. Aircraft designers, constantly seeking ways to overcome "bits-and-pieces" construction and to increase range, speed and pay load, today specify 17 per cent of the raw material stock in a standard U. S. fighter plane as extruded shapes, 23 per cent in patrol bombers, about 8½ per cent in commercial airliners.

As a pioneer in the production of aluminum extruded shapes for the past 50 years—with skill and knowledge accumulated operating four modern extrusion plants with a fifth now under construction for operation in 1954—we feel the following facts represent . . .

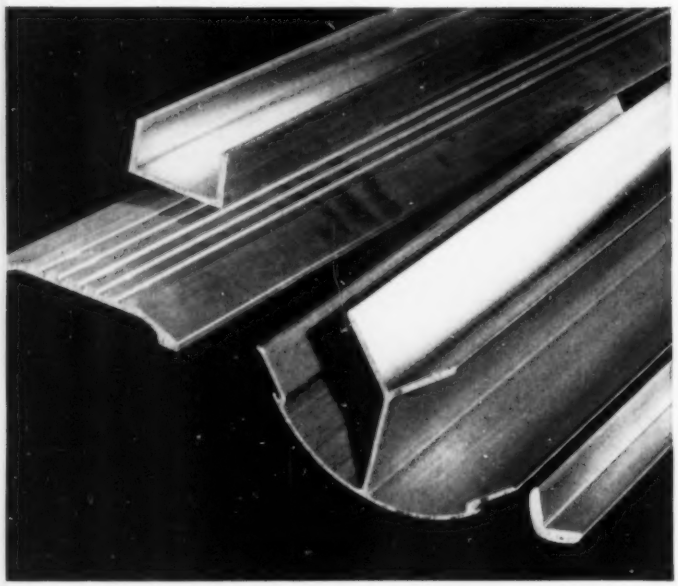
WHAT TOMORROW'S DESIGN SUPERVISORS SHOULD KNOW ABOUT ALUMINUM EXTRUDED SHAPES TODAY

VERNON (LOS ANGELES), CALIF.

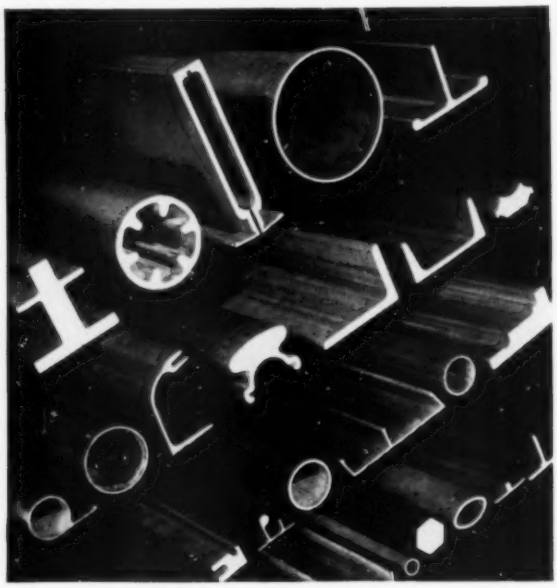
LAFAYETTE, IND.

CRESSONA, PA.

A few of the aluminum extruded shapes used by the building industry. Use of such extrusions as these results in cheaper, better and more modern construction.



Whether your needs call for shapes as they come from the press, or requiring further machining and finishing, or as stock for subsequent forging operations, there's an aluminum extruded shape that will do your job.



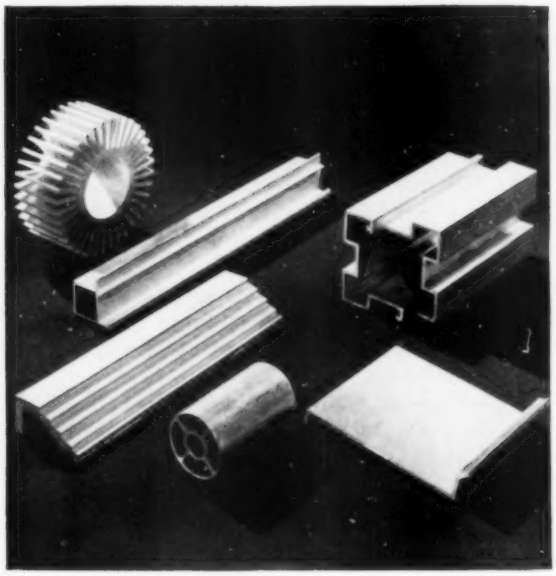
WHO USES ALUMINUM EXTRUDED SHAPES?

In any normal day you will probably pass, walk on or touch an extruded shape. Millions of feet of architectural and structural shapes are produced each year—for doors, windows, railings, beams, cornices and trim. Buses, trucks and trailers utilize extruded aluminum shapes as flooring, sills, posts and roof rails. Aircraft is made lighter, stronger, cheaper through the use of extruded spars, flooring, spar caps, interior trim, and often, exterior skin sections. The reasons behind the ever-increasing use of extruded shapes are first, that they provide the most efficient distribution of metal throughout a piece having a uniform cross section. And, that metal is placed exactly where it is needed to withstand stress. Or if a product was once assembled from many parts, chances are, as an extrusion, less time will be spent in assembly. Lower costs result. And often, expensive machining can be entirely eliminated.

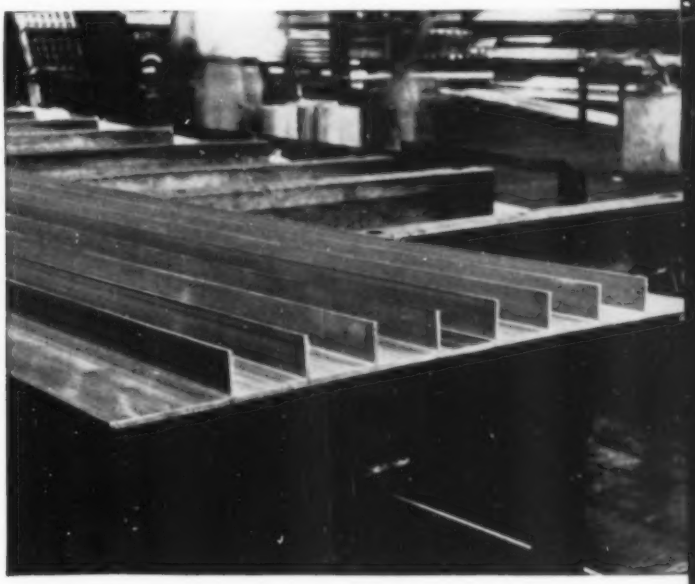
Full advantage of the extrusion process is realized in the production of complex shapes—the joining of thick and thin sections, or when design calls for compound curves and undercutting.

Extruded shapes fall into three general categories: those which, once extruded, are finished parts after being cut to length; parts finished but for simple machining operations and those cut into blanks for subsequent forging.

Aluminum extruded shapes offer the most efficient distribution of metal throughout a piece having uniform cross section. Metal can be placed exactly where it is needed to withstand stress. Full advantage of the process is taken in the production of complex shapes, joining thick and thin sections, use of compound curves and undercutting.



Exterior skin for aircraft. Piece is first extruded as a "V" shape within a 23-inch circumscribing circle, then flattened. This method, in addition to producing unusually large extrusions, avoids the necessity of fastening ribs or other strengthening members by mechanical means.



ABOUT COSTS

Die costs are usually low, varying from 120 dollars up. And dies for many standard shapes are kept on hand at Alcoa for your use at no cost at all. All the advantages extruded shapes offer in light weight and fewer assembly operations spell direct and indirect savings . . . fewer production man-hours are involved, stocking and inspection become easier, there is less tooling, and cheaper and better production control.

Remember that thin, intricate shapes, because they are generally more difficult to extrude, often cost more per pound. But their light weight, and the fact that as an extrusion they represent the best distribution of metal, keeps cost per piece low.

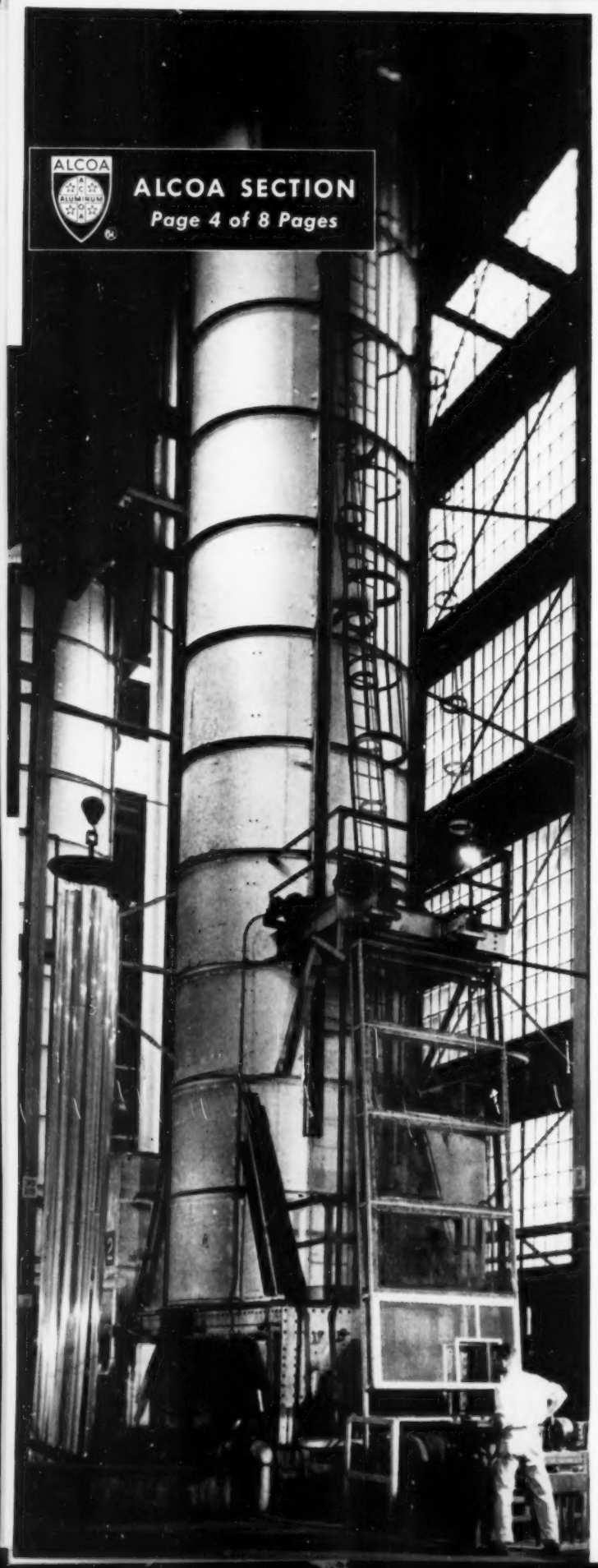
ABOUT PHYSICAL PROPERTIES

Aluminum extruded shapes are dense, homogeneous, highly worked shapes possessing a high degree of preferred molecular orientation with excellent tensile and yield strengths—higher than average for like shapes produced by other methods. Tensile and yield strengths depend to a large extent on alloy, temper, and the working the shapes receive in the extrusion process, especially heat-treatable alloys. Extrusions are considered to be wrought shapes because of the often severe volume reduction from ingot to finished part.

Kneading action of the process eliminates porosity, results in homogeneity of the metal structure. Surfaces are smoother, freer of pits than those produced by casting.

Thickness ranges from about 0.040 inch up to several inches with less than 0.040 inch produced occasionally. Relationship of thickness to width is governed by a thickness ratio that varies with the alloy. For example, 3S and 63S parts 8 inches wide should be no thinner than .093 inch; while 14S, if 8 inches wide, should be no thinner than .125 inch.

Tolerances, because of the nature of the process and usually involved product design, must be measured several ways: straightness, flatness, twist, section thickness, angles and contours, and corner and fillet radii. Generally, by specifying standard tolerances, cost can be held to a minimum.



ABOUT ALUMINUM ALLOY SELECTION

Generally, stronger alloys are more costly to extrude. So it is better to choose the softest alloy possible that matches the mechanical and physical requirements of your product.

Most commonly extruded alloy is the heat-treatable alloy, 63S. In the T6 temper, it develops 30,000 psi yield strength, 35,000 psi tensile strength, and is suitable for many applications. For greatest strength, alloys 24S and 75S are used. Though slightly more costly to extrude, their extra strength can more than pay its own way.

Alloys 2S and 3S are softer and, being non-heat-treatable, have low yield and tensile strengths. But they are among the easiest to extrude.

The accompanying table serves as an easy reference to typical mechanical properties developed by aluminum alloys suitable for extrusion.

Alloy	Temper	Tensile Strength Lbs./Sq. In.	Yield Strength Lbs./Sq. In.
2S	O	13,000	5,000
	F	14,000	6,000
3S	O	16,000	6,000
	F	17,000	7,000
14S	O	27,000	14,000
	T4	62,000	42,000
	T6	70,000	60,000
24S	O	27,000	11,000
	T4	68,000	47,000
61S	O	18,000	8,000
62S	O	17,000	7,000
61S & 62S	T4	35,000	21,000
	T6	45,000	40,000
63S	T42	22,000	13,000
	T5	27,000	21,000
	T6	35,000	30,000
75S	O	33,000	15,000
	T6	82,000	72,000

One of several large Alcoa heat-treating furnaces. Quenching bath beneath the furnace is as deep as the furnace is tall.

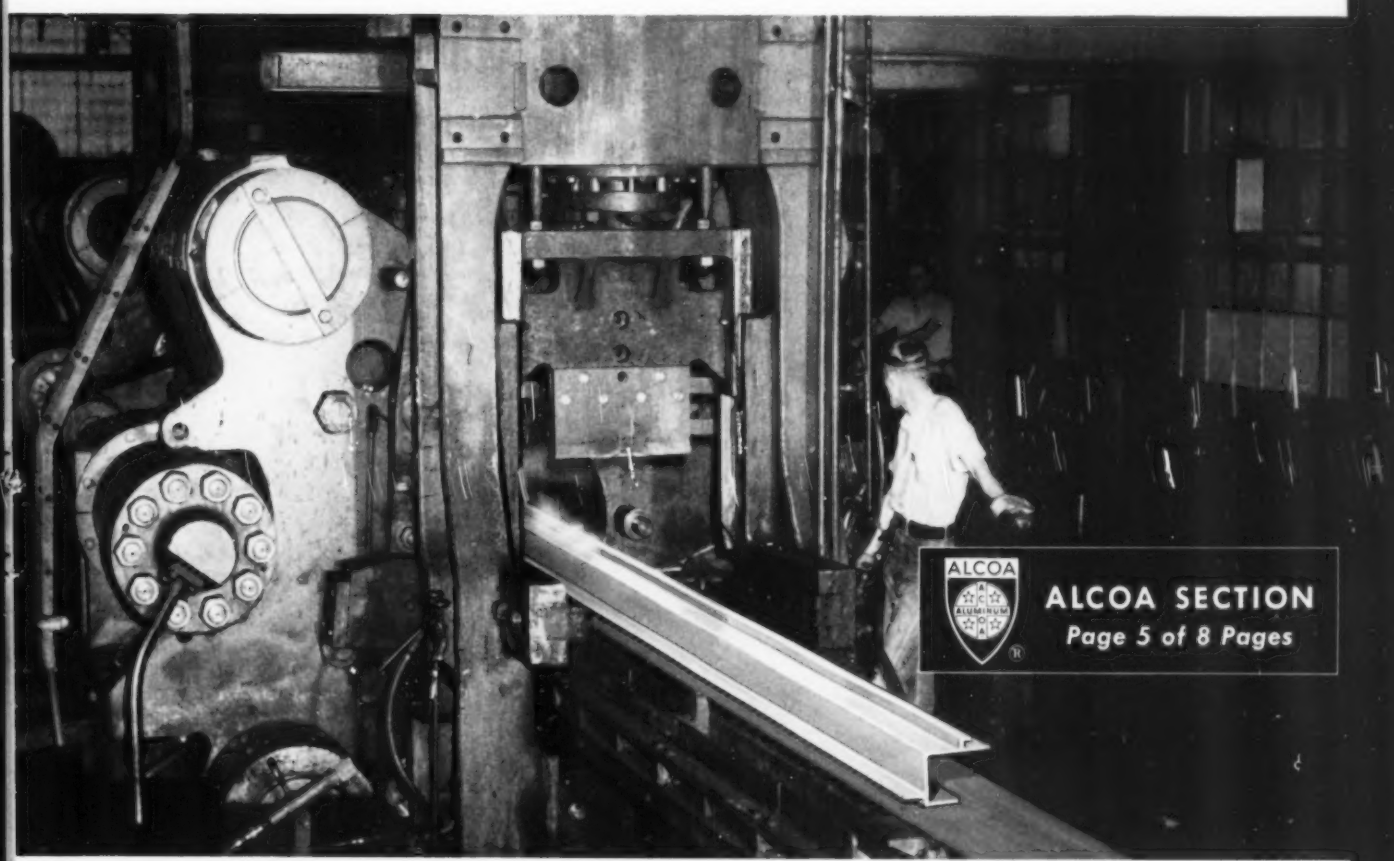
ABOUT MAGNESIUM ALLOY EXTRUDED SHAPES

Mechanical properties of extruded magnesium shapes exceed those for magnesium parts in any other form, cast or wrought. And their lightness makes them ideal for aircraft, materials handling equipment and transportation vehicles where their strength and other characteristics permit.

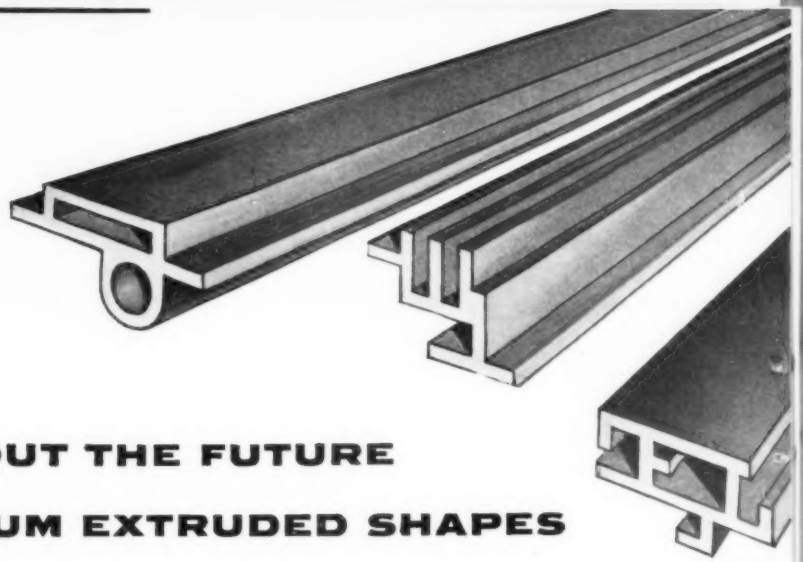
Most widely used of all magnesium alloys for extrusion is alloy AMC3S. For higher strength, AMC52S. Highest strength is achieved with AMC58S. The latter, however, cannot be used for hollow shapes. Alloy AMC57S gives best weldability.

Accompanying is a table listing magnesium alloy strength characteristics. Use it as a help in selecting the proper alloy for your product.

Form	Alloy	Condition	Mechanical Properties—Psi	
			Ultimate Strength	Yield Strength
Extruded Shapes	AMC3S	F	37,000	28,000
	AMC52S	F	38,000	28,000
	AMC57S	F	43,000	31,000
	AMC58S	F	48,000	36,000
	AMC58S	T51	54,000	39,000



One of Alcoa's 50 extrusion presses in operation.
Generally, stronger alloys are more costly to extrude. So choose the softest alloy that matches the physical and mechanical requirements of your product.



ABOUT THE FUTURE of ALUMINUM EXTRUDED SHAPES

Look for big things to come in this field—mainly in the form of bigger presses. There is a 14,000-ton extrusion press now being installed in one of the Alcoa plants. This 14,000-ton press is the largest in existence in the United States and will be in operation by the end of 1953. And Alcoa is installing a 3,000,000-pound stretcher to go with the new extrusion press.

Manufacturing possibilities for this press and stretcher facilities are far beyond Alcoa's Standard Manufacturing Limits for extruded shapes. The accompanying table will indicate these manufacturing possibilities.

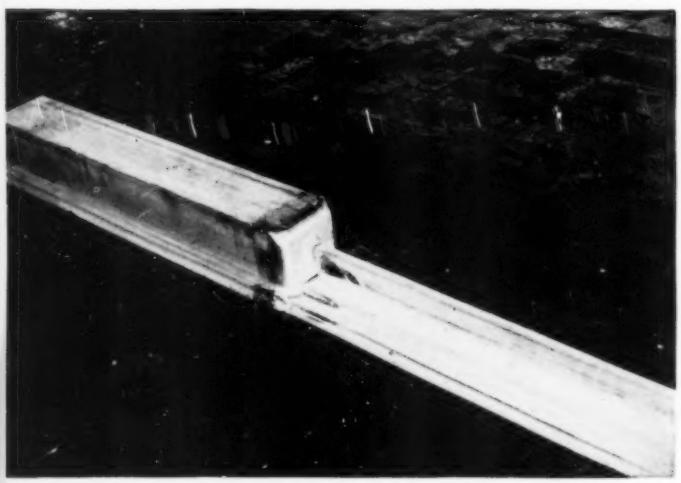
To designers, and especially aircraft designers, bigger presses mean higher pressures. Higher pressures mean such things as thinner webs, greater intricacy, and refinement of parts, smaller fillet and corner radii, greater structural loads, smoother finishes, thinner airfoil sections.

Wide, ribbed extruded shapes are useful for wing panels and bulkheads in aircraft, bulkheads and hatch covers in marine construction, curtain walls and spandrels in architecture.

Much experimentation has been conducted with tapered wall and stepped extruded shapes. Although the latter are now commonly made, a method for producing consistently accurate, tapered extruded shapes has yet to be perfected. But when it is, Alcoa and its enlarged facilities, now in the planning stage, will be producing them.

Today production engineers, when producing large extruded shapes, are faced with such problems as decreased extrusion ratios and slower quench rate from solution and heat treatment, both of which tend to lower mechanical properties. These problems, too, will be lessened by the large 14,000-ton press and its collateral facilities.

Certainly higher-grade forging stock will be produced, and new techniques will be developed combining the extrusion and forging processes to permit design and fabrication of parts far more complex and possessing greater mechanical properties than those attainable today.



Typical stepped extrusion now being produced by Alcoa's extrusion plants.

Maximum *weight* per piece . . . . . 2,300 pounds
Maximum *length* per piece, heat treated: . . . 110 feet
Maximum circumscribing circle diameter of *cross section:* . . . . . 23 inches
Maximum *thickness:*

Circumscribing circle diameter, inches	3S & 63S	61S & 62S	14S	24S & 75S
Under 13	.093	.109	.125	.156
13 to (not incl.) 16	.109	.125	.156	.187
16 to (not incl.) 19	.125	.140	.171	.250
19 to (not incl.) 23	.140	.156	.187	.375

Manufacturing possibilities with 14,000-ton press and 3,000,000-pound stretcher, both to be in operation soon.

Alcoa will work with you to simplify design and construction, thereby giving you better parts at less cost.

ABOUT DESIGNING FOR ALUMINUM EXTRUDED SHAPES

Extrusion permits you to reproduce in metal practically any cross section you can draw, solid or hollow, simple or complex, balanced or unbalanced. It's good to remember, though, that costs increase as you go from solid to semi-hollow to hollow.

The usual maximum weight per piece of Alcoa® Extruded Shapes is 600 pounds. This will become 2,300 pounds when the 14,000-ton extrusion press is in operation. The 12-inch maximum circumscribing circle diameter cross section, now the Standard Manufacturing Limit, can be almost doubled.

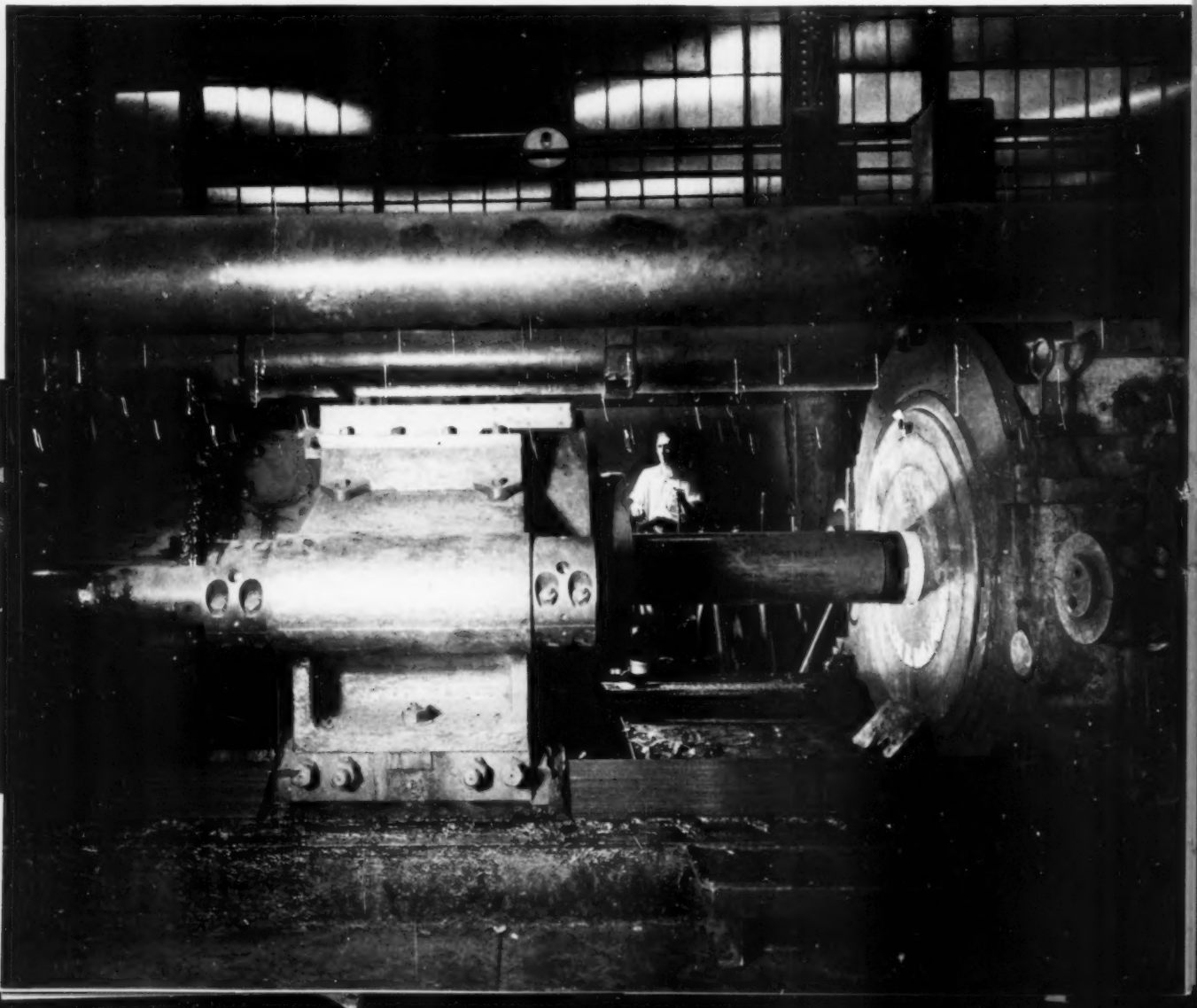
Too, semi-hollow sections with unbalanced die tongues cause production troubles. Designers should stay away from these and extreme thickness variations or hollow shapes having unsymmetrical voids with inadequate thickness between voids.

YOUR NEXT STEP

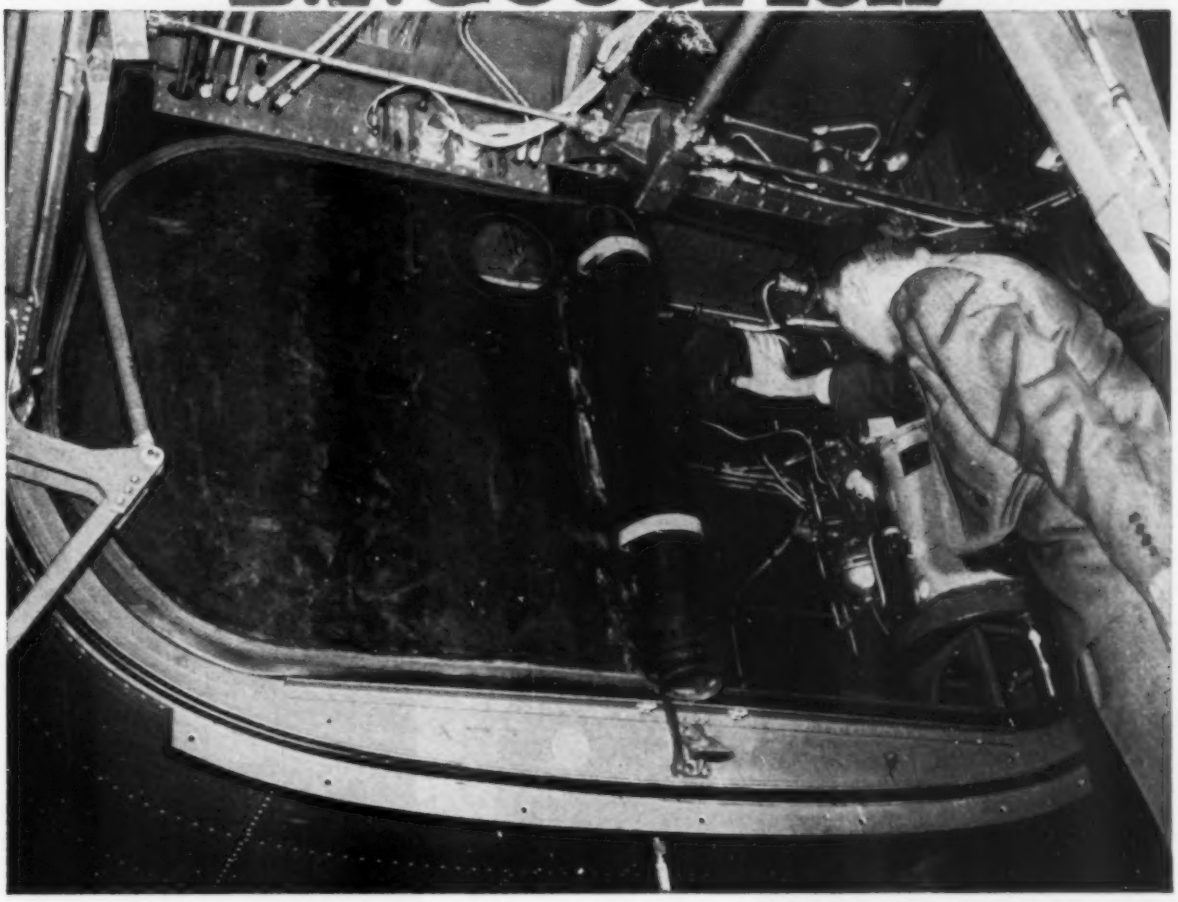
Write Aluminum Company of America,
1992-J Alcoa Building, Pittsburgh 19, Pa., for
our book, *Alcoa Aluminum Extruded Shapes*. Use your
company letterhead and be sure to let us know your job function.

Or, if you have some specific design problem now,
contact your local Alcoa sales engineer.
Don't hesitate to use his time and talents freely even if you don't plan
to buy extruded shapes next week, next month or next year.
You can locate him by looking under "Aluminum" in the
classified section of your telephone directory.

Extrusion permits you to reproduce in metal practically any cross section you can design, solid or hollow, simple or complex, balanced or unbalanced.



B.F.Goodrich



New zipper seals tight, zips open fast

A NEW *KIND* OF SEAL keeps gases, liquids, dirt *in* or *out*. In the picture, it is used to seal a curtain that keeps fumes from an airplane's engines out of the forward compartment. Getting inside in a hurry was often as important as sealing out the fumes. Other methods of sealing called for screws or other fasteners. They took time to remove. The new B. F. Goodrich Sealing Zipper did both jobs—sealed tight, opened fast.

Here's how it works: Rubber lips are molded with hairline precision so that they fit together tightly. They press together even without pressure to seal effectively. And with pressure against the lips, the seal actually tightens. The rubber seal is applied to an ordinary zipper which zips open or shut in a hurry.

The B. F. Goodrich Sealing Zipper is so flexible it goes around curves and odd shapes where clamps won't work. Can be made of compounds to resist weather, oils, gasoline, chemicals. Can be sewn or cemented to fabric, metal, wood, glass. The rubber can be made to match any color. Production costs are often reduced because the zipper is so easy to install.

It has been used in life-saving suits, to seal delicate instruments against moisture, to seal lifeboats against sea water, to seal auto convertible tops against rain. Write for complete details, sending blueprints or specifications of your products to Dept. A-67 or send coupon below. The B. F. Goodrich Company, Zipper Division, Akron, Ohio.

B.F. Goodrich

Airtight, Watertight Sealing Zipper

OVERLAPPING RUBBER LIPS IN THIS CROSS SECTION SHOW HOW ZIPPER SEALS

Send Now for Free Folder

Gives case histories, design advantages, suggested uses.

The B. F. Goodrich Company
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Address .....

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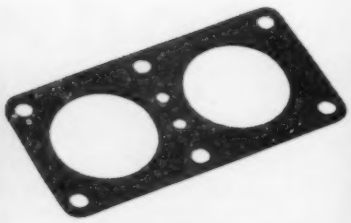
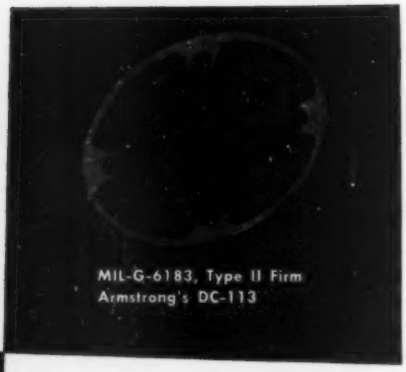
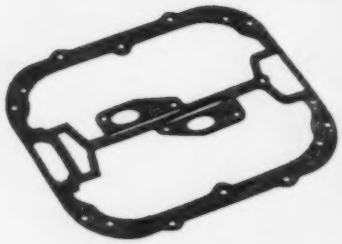
MIL-G-6183, Type II Soft
Armstrong's DC-167



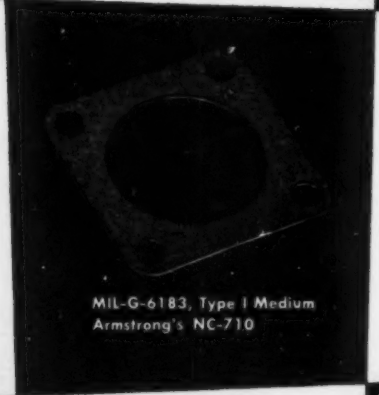
MIL-G-6747
Armstrong's DK-149



MIL-G-6183, Type II Firm
Armstrong's DC-113



MIL-G-6183, Type I Firm
Armstrong's NC-711



MIL-G-6183, Type I Medium
Armstrong's NC-710

MIL-G-6183, Type II Medium
Armstrong's DC-100

MIL-G-6183, Type I Soft
Armstrong's NC-709

MIL-T-6841
Armstrong's DK-153 and
RK-3048

MIL-G-17539
Armstrong's RK-375

These nine cork-and-rubber materials are made to meet government specifications

If you need a cork-and-rubber material to meet government specs, chances are one of these nine Armstrong materials will be the one you want. Each is made to meet one of the nine principal types of cork-and-rubber materials covered by government specifications.

For samples and full information, call your nearest Armstrong Industrial Division office or refer to the "Armstrong's Gasket Materials" section in Sweet's file for product designers.

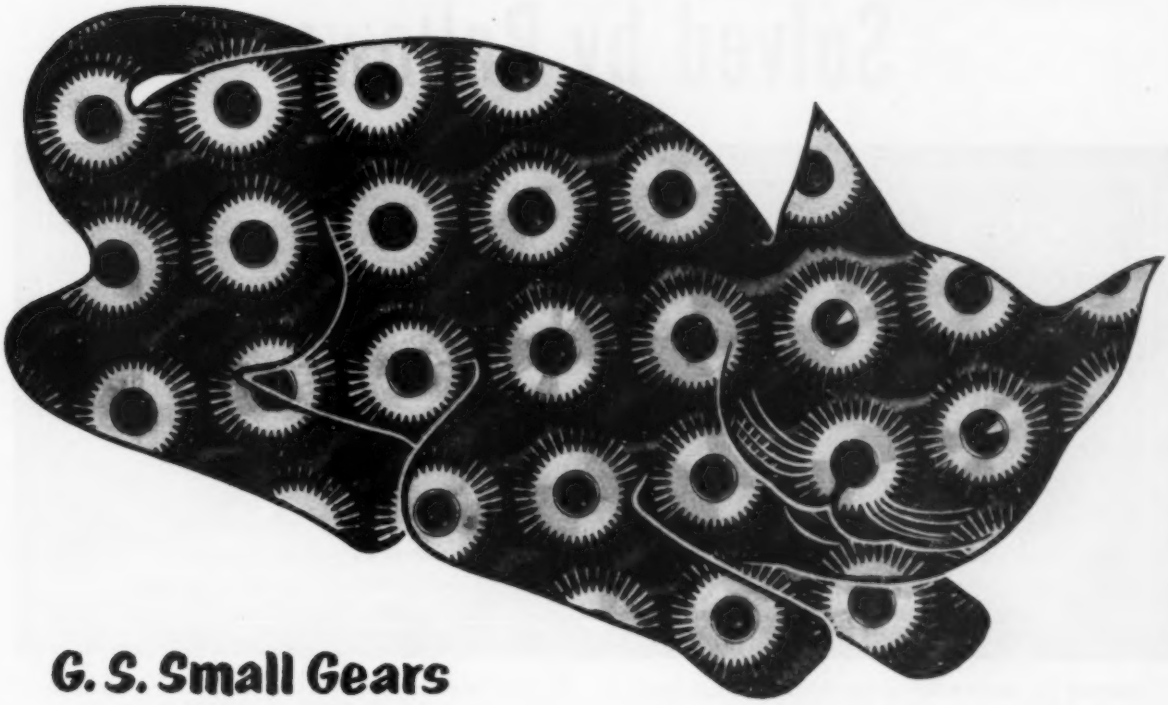
Free gasket data book. The 24-page manual, "Armstrong's Gasket Materials," gives information on current government specs and tentative SAE-ASTM specs. It has sections on cost reduction, gasket tolerances, flange design, and many other subjects.

Send for your free copy. Write to the Armstrong Cork Company, Industrial Division, 7109 Irvin Street, Lancaster, Penna.

Armstrong's Gasket Materials

GET OUR *Free* 6-PAGE FOLDER

See where and how we mass-manufacture Small Gearing to uniformly fine tolerances. This attractively printed 8½ x 11" 6-page folder is punched for ring-binder use. You'll want to keep it handy for frequent reference. It contains 23 pictures of Small Gears, plant views, as well as Diametral and Circular Pitch Tables. Ask for your copy on company stationery, please!



G. S. Small Gears

PUR-R-R Like a Kitten!

Smooth, quiet, *"purring"* performance is characteristic of the Fractional Horsepower Gearing we make! And no matter *what* the device or *how* the power is transmitted, you can depend upon these better Small Gears to give greater satisfaction and longer life to the product. G. S. have the distinction of over 30 years experience in the design and manufacture of Fractional Horsepower Gearing *exclusively!* Methods and machines have been perfected to a degree of efficiency and economy often considered impossible! Each Gear, in a production run of *thousands,* is precision produced to remarkable standards of accuracy and UNIFORMITY. You too can profit from the *consistently* finer quality of G. S. Gearing. Decide *now,* to let our skilled engineers and production craftsmen help you. Will you phone or write us today?

FRACTIONAL HORSEPOWER

GS

GEAR

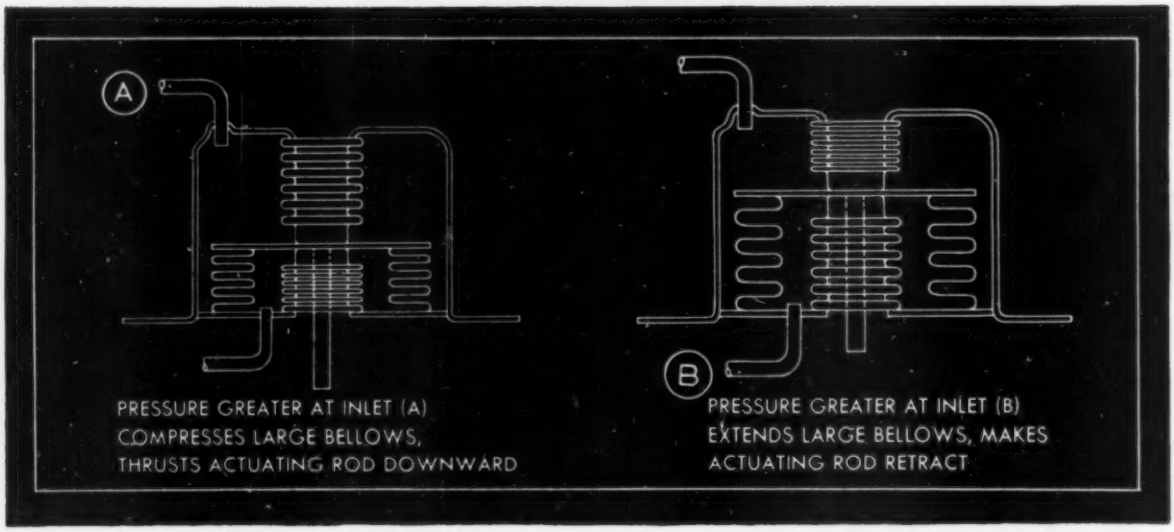
Specialties, Inc.

2635 WEST MEDILL AVENUE
CHICAGO 47, ILLINOIS

SPURS • SPIRALS • HELICALS • BEVELS • INTERNALS
WORM GEARING • RACKS • THREAD GRINDING

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS
OF FRACTIONAL HORSEPOWER GEARING

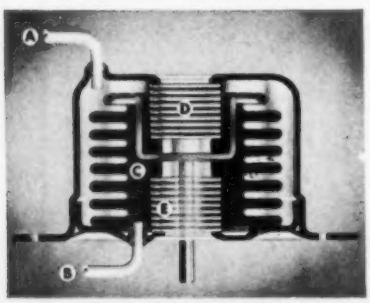
Differential Pressure Problems Solved by Bellows



AMONG THE MANY USES of the new differential pressure Clifford bellows assembly is the maintenance of absolute pressure in aircraft fuel systems. Manufacturers of thermostats or pressure switches which must not be affected by barometric changes due to altitude or other factors also find the new assembly an ideal control unit . . . for vapor pressure thermostats, for instance.

The assembly is useful, too, for flow indication or control. Pressure drop across an orifice or venturi can be used to "sense" flow in a closed system. A sensitive bellows can be used since the large bellows is subjected to differential pressure only.

Generally, the unit can be applied to all types of industrial processes where pressures within a fluid system must be automatically equalized or where absolute rather than gauge pressure must be maintained.



THIS CLIFFORD DIFFERENTIAL BELLOWS ASSEMBLY CONSISTS of large operating bellows (C) and two smaller sealing bellows (D), (E). Pressure can be applied at either side of large bellows. The movement of the actuating rod is then proportional to the *difference* between pressures on the inside and outside of the large bellows. Either side of the large bellows can also be evacuated and sealed. In this case, the movement of the rod is a function of *absolute* pressure. The rod is used to operate switches, valves or any similar devices to control an indicated differential or absolute pressure.

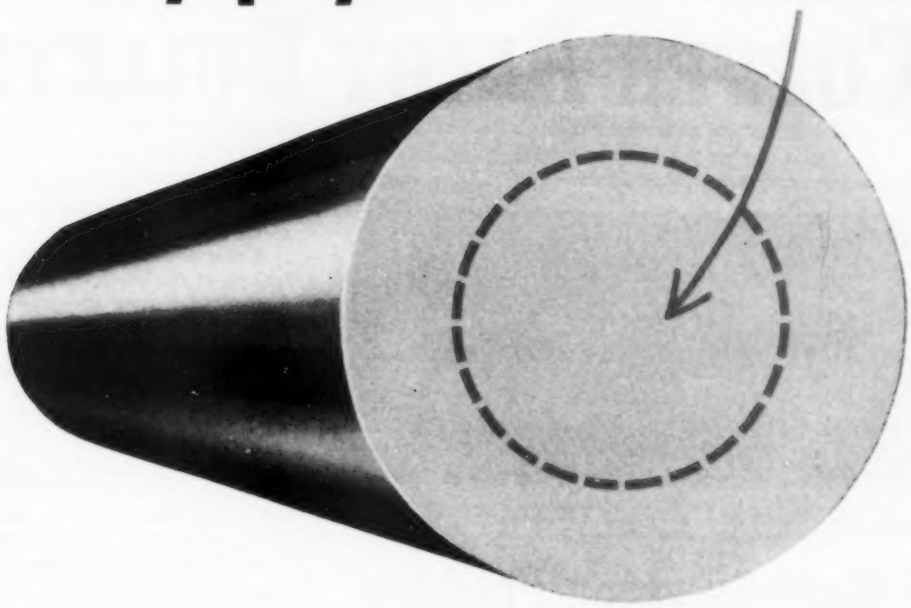
The assembly comes in a variety of materials . . . brass, stainless steel, monel or any metal having suitable drawing property for making bellows. It can be adapted to all combinations of sizes and pressures for which bellows are available. For further details, write direct Clifford Manufacturing Company, 122 Grove Street, Waltham 54, Massachusetts. *Division of Standard-Thomson Corporation.* Sales offices in New York; Detroit; Chicago; Los Angeles; Waltham, Massachusetts.

FLEXIBLE, LEAKPROOF, METALLIC, CLIFFORD BELLOWS are also used to

1. transmit motion between two mediums
2. control and indicate temperature
3. seal rotary shafts or packless valves
4. transmit motion hydraulically to remote points
5. provide for thermal expansion
6. provide shock mounting or vibration dampening
7. permit motion in a vacuum

HYDRON METAL BELLOWS — CLIFFORD MANUFACTURING CO WALTHAM, MASS — HEAT EXCHANGERS

Why pay for this waste...



when you make hollow parts?

THE center hole's already in Timken® seamless tubing. There's far less metal to machine away, far less waste. You save machining time—get more parts per ton of steel.

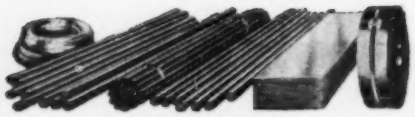
With Timken seamless steel tubing, finish boring is often the first production step. Screw machine stations can be released for other operations, giving you added machine capacity without additional machines.

To save you even *more* steel, the Timken Company's engineers will study your problem and recommend the most economical tube size for your hollow parts job—guaranteed to clean up to your dimensions.

Timken seamless tubing gives you high internal quality because the piercing process by which it is made is basically a forging operation. It has a uniform spiral grain flow for greater strength and a refined grain structure which brings out the best in the quality of the metal. And the Timken Company's rigid quality control keeps this quality uniform from tube to tube and heat to heat. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

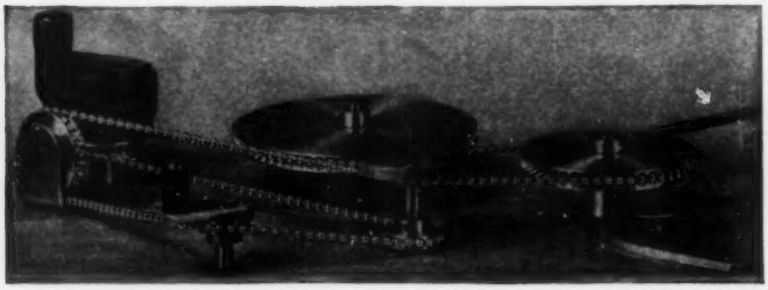
SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING



BRIDGEPORT BRASS COMPANY

COPPER ALLOY BULLETIN

Bridgeport BRASS CO. MILLS IN BRIDGEPORT, CONN. AND INDIANAPOLIS, IND.—IN CANADA: NORANDA COPPER AND BRASS LIMITED, MONTREAL

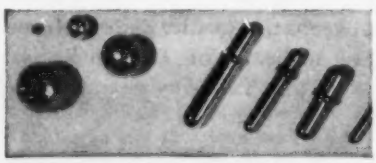


New low-cost Bead Belt — a sprocket drive for TV tuners, machines, etc. Timing and movement accurately controlled because slippage and backlash are avoided. Courtesy The Bead Chain Manufacturing Co., Bridgeport, Conn.

Uses of Multi-Swaging Products Challenge Imagination

Do you know that multi-swage products are among the most familiar items of everyday use? Examples are bead chain of a thousand uses; radio tube pins, terminals, jacks, contact pins and friction fasteners for electronic, electrical, and mechanical devices; stop pins, dowel pins, rest pins for appliances and novelties; spacers; shaft bearings for toys and other light duty applications.

Just how and where multi-swage products can be used advantageously



Multi-swage products—hollow tubular parts with tightly swaged seams — are widely used for contact pins, terminals, jacks, and sleeves. Friction fasteners made by this process retain their spring properties remarkably well. Courtesy The Bead Chain Manufacturing Co., Bridgeport, Conn.

for new applications in modern design is up to the imagination of designers and engineers.

Efficient and Economical

The multi-swage products illustrated are made by The Bead Chain Manufacturing Company, Bridgeport, Conn. They are mainly produced from annealed narrow width strip brass (70-30) of uniformly close tolerances for composition, temper, gauge and flatness. Strip is fed into an extremely ingenious but very complicated high-speed automatic machine. It operates similar in principle to the eyelet machine except that some of the stages are designed for multiple swaging. This operation causes the metal to flow into the proper form of the product design and results in an article which is extremely work hardened with accompanying great strength and stiffness.

Multi-swage products are hollow and have a longitudinal seam which remains tightly closed because of the stresses imparted from the swaging operation. When forced apart by a tapered pin, a strong spring pressure is developed. When the pin is removed, the seam closes tightly even after the above operation is repeated thousands of times. Sizes range up to a maximum of ¼" diameter and 1½" long.

Because of the minimum waste involved, and high speed of manufacture, the multi-swage method is more economical than other methods of manufacture for producing small tubular parts in large volume. Other advantages are dimensional accuracy and a variety of shapes. Fitting up charges for tooling, etc., for new items are surprisingly modest.

The New Bead Belt

Outstanding features of bead chains are nonkinking, low friction, and unusually great strength in proportion to its weight, especially in the small sizes. Tensile strength ranges from 15 pounds to 200 pounds depending upon size and metal used.

A new development in the accurate spacing of the beads and an ingenious method of closing the ends has led to the manufacture of a belt drive from bead chain. Specially designed sprockets fit the individual beads and eliminate slippage and backlash. Timing and movement of various parts are accurately controlled.

It is being applied in TV tuners, eliminating costly gearing mechanisms. Other applications are for timing devices, recorders, air conditioners, etc.

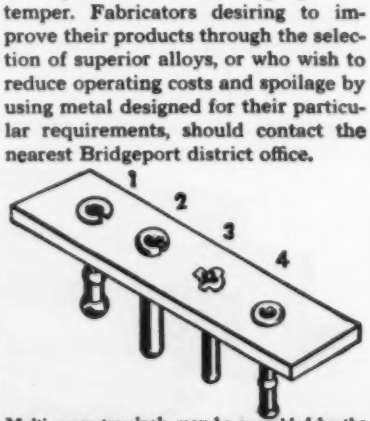
Many Alloys Used

Aside from brass, other alloys are used. Nickel Silver (copper 65%, nickel 18%, zinc remainder) is excellent as a white base for silver plated goods or for higher strength.

For decorative jewelry, Red Brass (85% copper, 15% zinc), and Commercial Bronze (90% copper, 10% zinc) are used because of their rich, golden colors.

For high strength and resistance to corrosion and wear, Silicon Bronze 609 (98% copper and 2% silicon) and Phosphor Bronze 35 (95% copper, 5% tin and 0.15% phosphorus) are recommended.

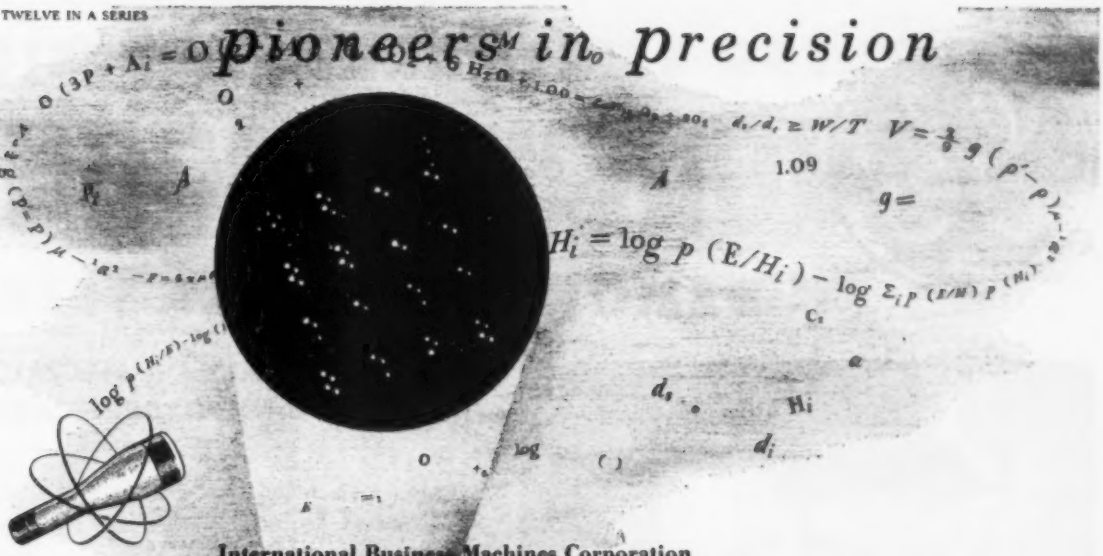
Bridgeport Brass Company is always glad to work with customers who have special metal requirements, as exemplified by multi-swage process which calls for careful control of uniformity and accuracy in gauge and temper. Fabricators desiring to improve their products through the selection of superior alloys, or who wish to reduce operating costs and spoilage by using metal designed for their particular requirements, should contact the nearest Bridgeport district office.



Multi-swage terminals may be assembled by the following methods: 1. flared; 2. rolled; 3. slitted, or 4. spun. Courtesy The Bead Chain Manufacturing Co., Bridgeport, Conn. (336)

NO. TWELVE IN A SERIES

pioneers™ in precision



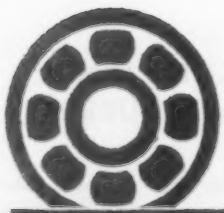
International Business Machines Corporation
recently installed the first production model of the IBM high-speed electronic calculator, the "701." Most recent successor to the pioneer large-scale digital calculator first developed by IBM in 1944, the "701" solves in minutes a problem which would take one man, using a desk computer, seven years to complete.

Miniature Precision Bearings, Incorporated,
are the originators and pioneer developers of precision ball bearings in miniature sizes (1/10″ to 5/16″ o.d.). Exclusive MPB methods assure thousands of discriminating customers ultra quality bearings for vital equipment.

MPB ball bearings supply the unerring accuracy and proven dependability necessary in providing many devices with anti-friction qualities. MPB ball bearings function effectively with deft delicate responsiveness under extreme operating conditions. They are fully ground, lapped, honed, and/or burnished to ABEC 5 tolerances or better.

The possibilities offered by MPB ball bearings are being profitably explored by leading instrument makers of the future. We would welcome the opportunity to discuss the matter with you. Branch offices in New York and Boston and Engineering Representatives in Principal Cities are eager to serve you. Ask for detailed data sheets **PE9.**

Immediate delivery on most sizes and plant capacity to promptly meet your additional requirements.

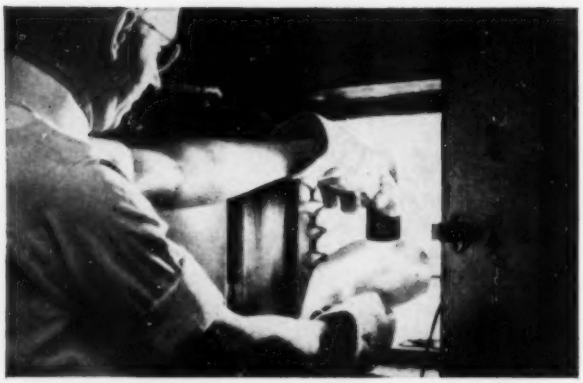


Miniature *precision* Bearings

Incorporated MPB Keene, New Hampshire

"pioneer precisionists to the world's foremost instrument manufacturers" { *save space weight friction*

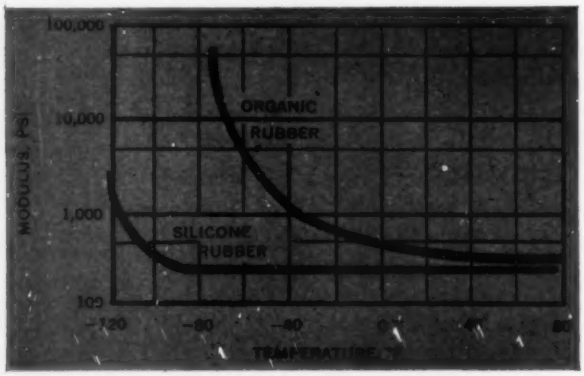
REMARKABLE DESIGN
NEW SILICONE
DEMONSTRATED BY TEST...



High temperature resistance: Elevated temperatures have no appreciable effect on the 1000-1200 volts per mil dielectric strength of glass cloth coated with SE-100.

SE-100 —IDEAL FOR ELECTRICAL AND MECHANICAL APPLICATIONS!

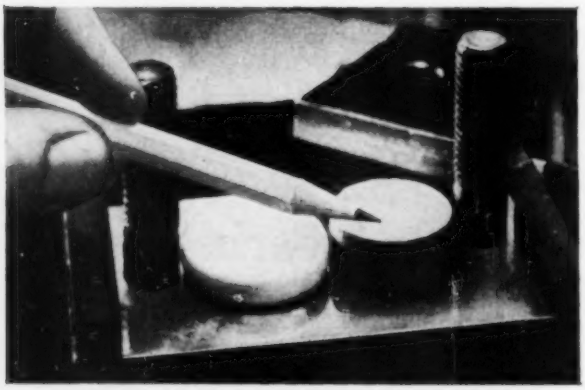
General Electric's new silicone rubber coating compound, SE-100, combines outstanding heat resistance, electrical and physical properties for a wide variety of electrical and mechanical applications. SE-100 may be coated on glass or organic fabrics for service at high or low temperatures or where resistance to weather, ozone, corona or chemicals is required.



Flexible at −120 F: A glance at the blue curve shows the difference (Young's Modulus in flexure) of SE-550 versus organic rubber after 24 hours.

SE-550 —STILL FLEXIBLE AFTER 24 HOURS AT —120 F!

G. E.'s new extreme low-temperature silicone rubber, SE-550, combines high strength and elongation with maximum low-temperature usefulness. SE-550 shows practically no increase in modulus at −100 F and retains useful flexibility at −120 F. This flexibility is achieved without sacrifice of high-temperature resistance or any of the other desirable properties inherent in silicone rubber.

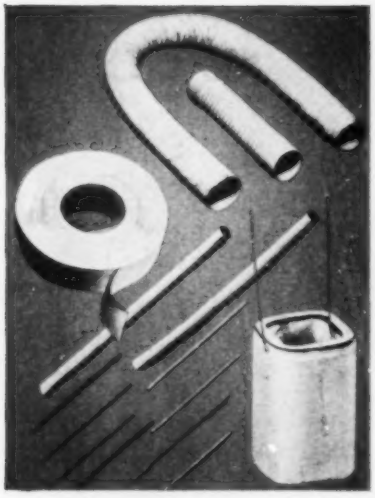


Compression test: Same-size pieces of ordinary silicone rubber and SE-360 are compressed for 22 hrs. at 350 F. Note how SE-360 (right) "comes back" to original size.

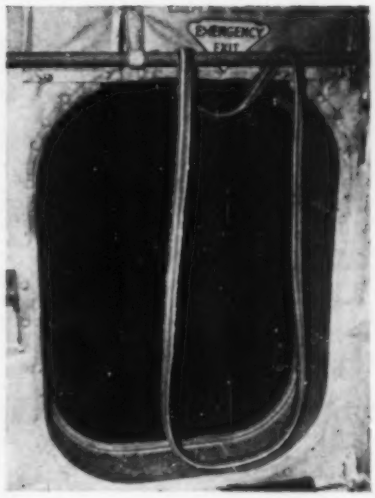
SE-360 —MORE "COME BACK" THAN ANY KNOWN RUBBER!

G. E.'s new low compression set silicone rubber, SE-360, is designed to provide more positive sealing action in parts subject to compression at elevated temperatures. In addition to its outstanding low compression set, SE-360 has unusually low shrinkage when cured. This means parts with more uniform properties, closer tolerances and opportunities for your fabricator to cut scrap loss.

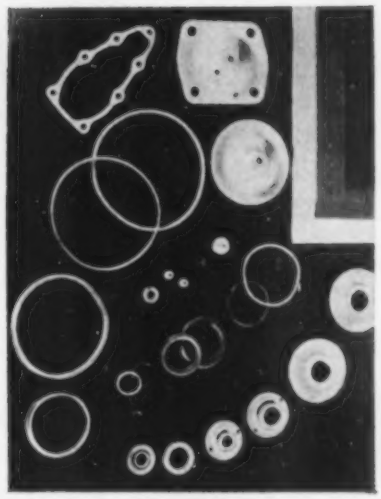
POSSIBILITIES OF THREE GREAT
RUBBER COMPOUNDS
CONFIRMED BY APPLICATION



G.E.'s SE-100 silicone rubber is finding steadily increasing application in the electrical industry for coating cloth, tapes and sleeving; for coating glass-served wire; for encapsulating coils. Among the many mechanical uses for SE-100 are ducts and tubing; gaskets and seals; diaphragms.



Gaskets for emergency hatches (shown here at 50 below zero F) astra domes and access windows on the Douglas Globemaster are now made of G.E.'s SE-550 silicone rubber because it remains flexible and maintains a seal at extremely low temperatures; does not stick to metal after long inactivity.



O-rings, gaskets and seals are being designed with G.E.'s new SE-360 silicone rubber for applications where sustained resilience at high temperatures is required. Aircraft, automotive and railway design engineers find SE-360 ideal for jet engine parts, transmission seals and Diesel gaskets.

CLIP AND MAIL TODAY!

FOR MORE INFORMATION

about these new G-E silicone rubber compounds, just mail the coupon! You will also receive a free copy of "Imagineering with Silicone Rubber" which describes other G-E silicone rubber products and tells how you can put them to work.

You can put your confidence in—

GENERAL ELECTRIC

General Electric Company
Section 1353-6B
Waterford, New York

Please send me product data on ( ) SE-100 ( ) SE-550 ( ) SE-360, including a free copy of "Imagineering with Silicone Rubber." I want this information for ( ) Reference purposes only ( ) An immediate application on

_____

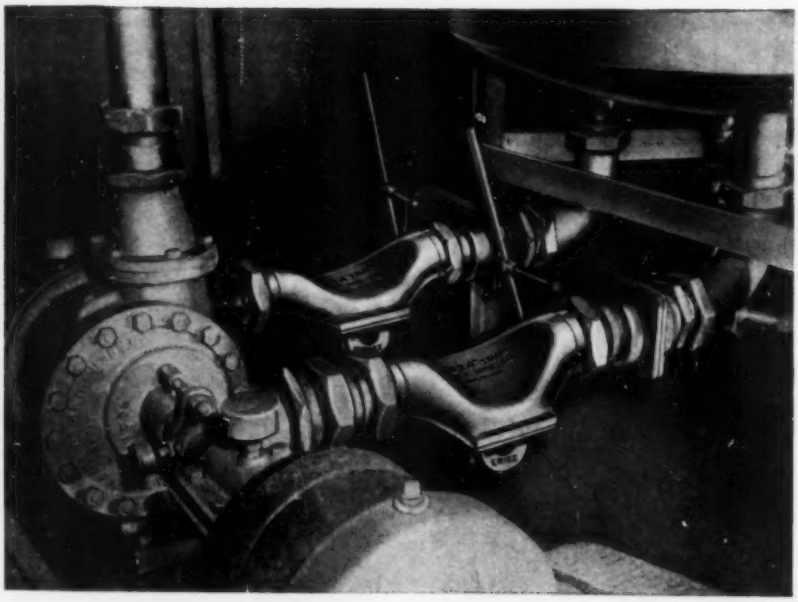
Name_____

Firm_____

Street_____

City_____ Zone____ State_____

(In Canada, mail to Canadian General Electric Company, Ltd., Toronto)



ERIEZ MAGNETIC PIPELINE TRAPS, widely used in the process industries, provide the superior magnetic strength of a high nickel alloy . . . ALNICO . . . to assure positive trapping of tramp iron. Housings are non-magnetic chromium-nickel stainless steel castings . . . leak-proof, easy to install and simple to clean. Completely non-electric . . . first cost is last cost . . . since magnets hold strength during life of equipment.

1,045 PIECES OF TRAMP IRON REMOVED ahead of vane-type displacement pump in food production line during a 30-day period, by an ERIEZ Permanent (non-electric) Magnetic Pipeline Trap.

Prevent

→ *Machinery Damage*
→ *Product Contamination*
→ *Production Tie-Ups*

. . . Automatically, with Eriez Magnetic Traps

Look at this pile of tramp iron . . .

Trapped ahead of a pump in a large food plant during a 30-day processing period . . . it exemplifies how "protection plus" is obtained automatically with pipeline traps produced by ERIEZ MANUFACTURING COMPANY, Erie, Pa.

To keep liquid flow lines free of ferrous materials ranging in size from minute particles to large pieces of tramp iron, ERIEZ pipeline traps utilize the strong magnetic properties of Alnico permanent magnets containing a high percentage of nickel.

Use of this aluminum-nickel-cobalt-iron alloy not only permits trap designs that eliminate need for electromagnets requiring current and accessory equipment, but its use also allows reduction of space and weight requirements to desirable limits.

The addition of nickel . . . an essential in Alnico . . . improves scores of other alloys utilized throughout industry. Consult us on use of nickel or nickel alloys in your products or equipment.

Send details of your metal problems for our suggestions.

At the present time, nickel is available for end uses in defense and defense supporting industries. The remainder of the supply is available for some civilian applications and governmental stockpiling.

EMBLEM OF INCO SERVICE

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

OIL RESISTANCE

ABRASION RESISTANCE

LOW COMPRESSION SET

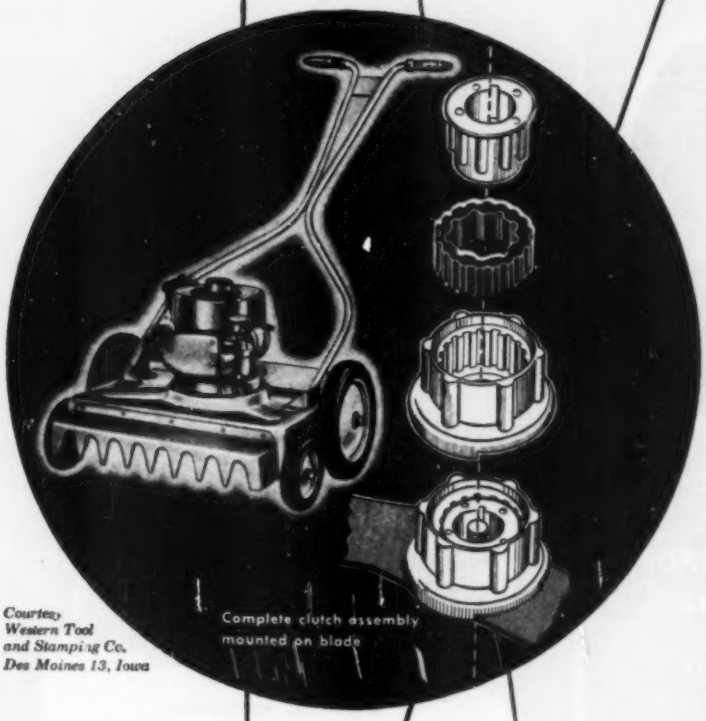
These properties of neoprene make a better

ROTARY LAWNMOWER

Rough ground and solid objects are no threat to the blade and engine crankshaft of this lawnmower—thanks to a shock-absorbing clutch. It consists of a fluted neoprene ring set between two concentric metal sleeves. The inner sleeve is keyed to the crankshaft . . . the outer sleeve to the blade.

Should the blade strike an obstruction, the neoprene ring remains locked to the vertical serrations of the outer sleeve, while the inner sleeve and the crankshaft continue to rotate. The flutings on the inner sleeve are rounded, permitting them to squeeze past the resilient neoprene ring, deforming it and absorbing the shock. After the obstacle has been removed, the inner flutings re-engage the ring and automatically "reset" the clutch.

Neoprene was specified for this critical ring because it withstands severe abrasion and resists attack from lubricating oil. And its low compression set means this ring will retain its shape despite the constant pressure and shearing action of the sleeves. Here, as in so many cases, the remarkable properties of Du Pont neoprene help make a design successful—so successful that this clutch is being adopted by many other manufacturers.



Courtesy Western Tool and Stamping Co. Des Moines 13, Iowa

Complete clutch assembly mounted on blade

PROPERLY COMPOUNDED NEOPRENE WILL RESIST:

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

NEOPRENE

The rubber made by Du Pont since 1932

FREE! THE NEOPRENE NOTEBOOK

Each issue shows new, unusual applications of neoprene . . . new products . . . improved designs. The neoprene application cited above is covered in detail in Notebook No. 53. Add your name to the mailing list today.

E. I. du Pont de Nemours & Co. (Inc.)
Rubber Chemicals Division PE-9, Wilmington 98, Del.

Name_____ Position _____

Firm_____

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City_____ State_____

2 EXCLUSIVE FEATURES OF ROCHESTER PRODUCTS

WELDED STEEL

GM tubing

LESS "SHORT END" WASTE

FEWER JOINTS—
LESS CHANCE OF LEAKAGE

LOWER PRODUCTION COSTS

Only GM Welded Steel Tubing is available in 1500-2000 foot random coils . . . as well as in straight lengths, or formed to your specifications. Sizes from 1/8" to 5/8" O.D., in a choice of plain, Terne coated, copper plate, or exclusive GM copper Fuse-Kote finish.

Mass-produced by Rochester Products at the rate of *hundreds of thousands of feet daily*, GM Steel Tubing lends itself to all types of fabricating operations. We believe it will pay you to consider its many time-and-money-saving features!

COPPER PLATING

In GM Steel Tubing, Rochester Products offers you the *only* steel tubing available with *COPPER PLATING*. Without adding copper, you can braze the tube to other parts such as fins or plates. One user reports material savings of 1200%!

- **BRAZE without adding copper**
- **SAVE time and material**

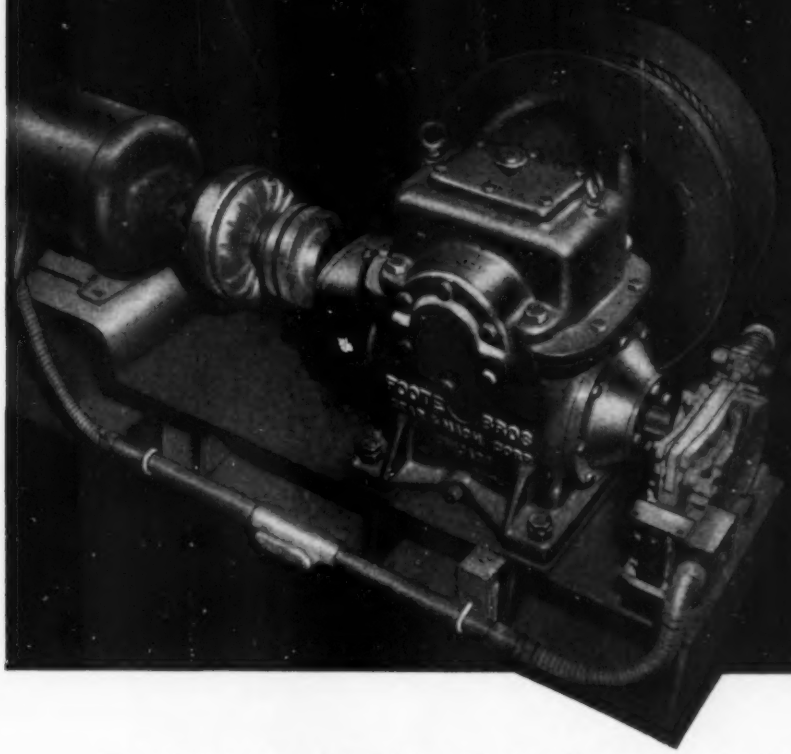
SEND FOR *Free* BROCHURE

Entitled *"Better Products for Greater Progress!..."* this new, illustrated, fact-packed brochure tells how GM Steel Tubing can help solve design and production problems. Send for your free copy today.

RP GM STEEL TUBING

ROCHESTER PRODUCTS, *DIVISION OF GENERAL MOTORS*, Rochester, N. Y., U. S. A.

TOUGH JOBS MADE EASY...



WITH FOOTE BROS. HYGRADE DRIVES... MORE STAMINA IN LESS SPACE

Horizontal Hygrade Drive operating door-control cable of open hearth furnace at Fairless Works, United States Steel Corporation. For purposes of illustration, safety guard over coupling has been removed.

Steel making is a rugged, 'round-the-clock job. And Foote Bros. Hygrade Drives have the stamina for such typical, tough service — like this Hygrade at U. S. Steel's Fairless Works.

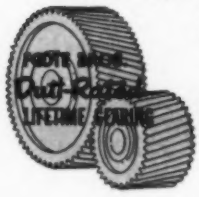
Sturdy, compact Hygrade Drives are built especially for heavy-duty applications — ratios range up to 4,108 to 1, capacities up to 260 h.p. But Enclosed Hygrade Drives are also designed to meet area limitations — modern, space-saving housings have been engineered around new-process, high-efficiency worm gearing to assure maximum performance in minimum space.

For optimum load-carrying capacity — for maintenance-free operation — for day-after-day service under the most rugged conditions... select Foote Bros. Hygrade Worm Gear Drives. There's a complete line — a size and type to meet all your requirements. Available with either horizontal or vertical output shaft. For special applications, Vertical Hytop Hygrade provides a long, extended, output shaft without additional support. For prompt delivery, call your Foote Bros. representative or write for bulletin.

Line-O-Power Drives

Foote Bros.-Louis Allis Gearmotors

Maxi-Power Drives



This Trademark Stands for the Finest in Industrial Gearing

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
4545 South Western Boulevard • Chicago 9, Illinois

Foote Bros. Gear and Machine Corporation
Dept. W, 4545 South Western Blvd., Chicago 9, Illinois

Please send Bulletin HGB. I understand it contains full information on Hygrade Drives.

Name.....

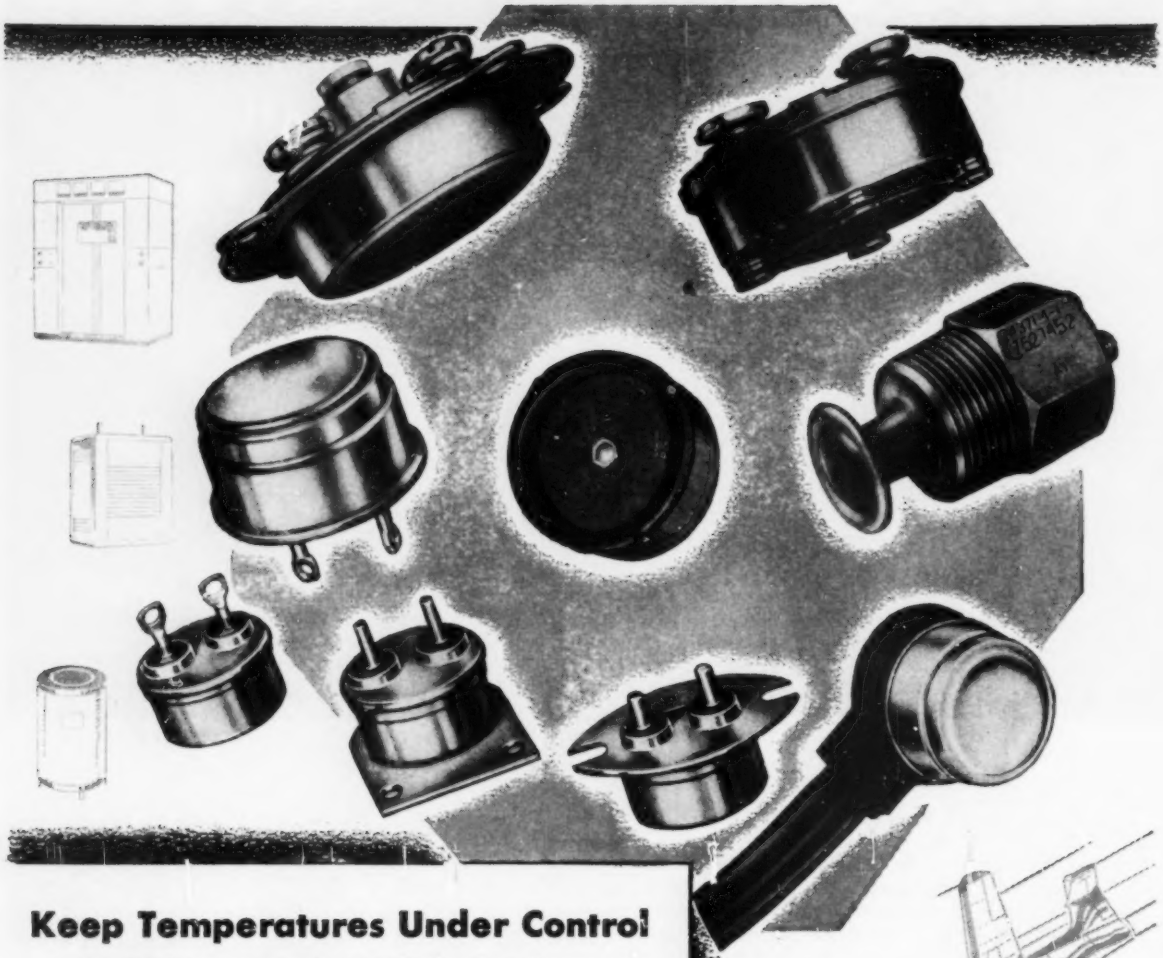
Position.....

Company.....

Address.....

City..... Zone..... State.....

KLIXON Thermo® Snap CONTROLS



Keep Temperatures Under Control

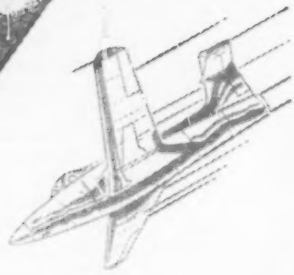
in Military and Civilian Products

Today . . . in practically every industry . . . Klixon Snap-Acting Thermo-Snap Controls are meeting the requirements for dependable, trouble-free performance in temperature control applications.

The reason for their wide acceptance is the actuating element . . . the scientifically calibrated Spencer thermostatic disc. This simple, foolproof element instantly snaps the circuit open with a quick break or snaps it closed to a solid make. It eliminates toggles, magnets and other complicated parts and is particularly suitable for use involving motion, altitude, shock and vibration . . . regardless of mounting position.

Klixon Thermo-Snap Controls, hermetically sealed and open types, are available in many types, shapes and sizes, in a wide variety of operating temperature ranges.

Write for complete information.

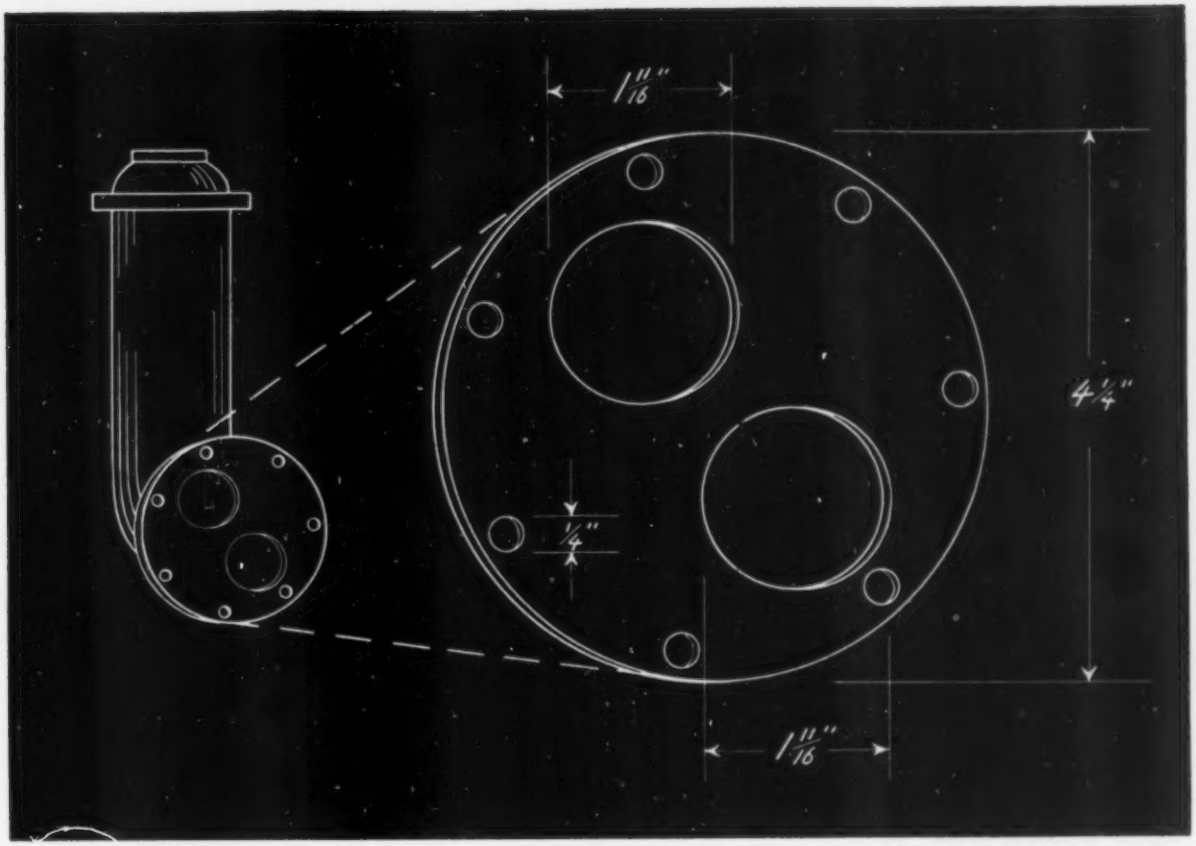


KLIXON

SPENCER THERMOSTAT

Division of Metals & Controls Corporation

909 FOREST ST., ATTLEBORO, MASS.



This fiber gasket seals perfectly even on a rough milled surface

A manufacturer had the problem of making a tight seal between the oil cooler and the cylinder block on a diesel engine. Since machining a smooth finish on the milled cylinder block would be expensive, he hoped to find a gasket that would give a tight seal against the block's uneven surface.

At first he had nothing but trouble and oil leaks. Then he tried an entirely new kind of fiber gasket material—Armstrong's Accopac®. This new fiber gasketing has the compressibility needed to make a positive seal even where pressure is relatively low.

Cork particles make it compressible. Finely ground cork particles—thousands of them—are added to Accopac's fiber and latex composition for extra compressibility. Accopac conforms to every surface irregularity and is especially useful in preventing distortion on light flanges where bolt pressures must be kept low.

Won't shrink, won't grow. Accopac overcomes another common difficulty of fiber gaskets—the tendency to lose the binder due to the solvent action of hot oil. Accopac gaskets won't shrink, dry out, or leak in any recommended application.

Each fiber and cork particle is literally locked in rubber by coating it with latex *before* the sheet is formed. For this reason, Accopac isn't materially affected by changes in humidity or temperature. You can store Accopac replacement gaskets for months and still have them fit and seal perfectly.

Write for samples. You may find Accopac helpful in reducing costs or replacing an unsatisfactory gasket. Accopac is available in sheets, rolls, ribbons, or die-cut shapes. For samples, call your nearest Armstrong office or write us. Armstrong Cork Company, Industrial Division, 7009 Irvin Street, Lancaster, Pennsylvania.

ARMSTRONG'S ACCOPAC

Enter the Peerless

Win a fine camera in the Peerless Photocopy-in-Industry contest.
Contest lasts for three months. Complete set of prizes awarded each month.

1st PRIZE **Contessa 35 Tessar f/2.8 . . retail price $216.00**
(choice) **Ikoflex IIa Tessar f/3.5 . . . retail price $216.00**

2nd PRIZE **Contina I 35 Tessar f/2.8 . retail price $119.00**
(choice) **Ikoflex Ia Novar f/3.5 . . . . retail price $125.00**

3rd PRIZE **Nettar IIc Novar f/6.3 . . . . retail price $ 41.70**

The cameras listed above will be sent to the winners of this contest at absolutely no cost. All cameras come complete with top-grain leather carrying cases. All carrying charges prepaid.

The contest is open to everyone actively interested in industrial photocopy.

HERE'S HOW YOU CAN WIN

Write a report on one of the photocopy applications or photocopy techniques that you find most valuable in your business. There is no limit to the length of your report. It can be supplemented with examples of the result achieved, sketches of the process, anything which you feel will lead to a full appreciation of your use of photocopy. Although originality is important, the significance of the result achieved will determine the winners.

Example: Suppose you use photocopy to eliminate certain drafting steps such as the redrawing of an entire part in order to make a simple change. Tell in your report exactly what steps you take to get the desired result. Tell also what this means to your drafting department in terms of time saved. Name the paper and machines involved in your process, and tell why you use them. Remember, the more complete and understandable your report, the better your chances are of winning.

CONTEST CLOSING DATES

To qualify for the 1st month's awards, entries must be postmarked no later than October 10, 1953. Winners will be notified by mail as soon as each month's judging is completed.

To qualify for the 2nd month's awards, entries must be postmarked no later than November 10, 1953.

To qualify for the 3rd month's awards, entries must be postmarked no later than December 10, 1953.

THE JUDGES

The contest will be judged by the executive board of Industrial Photography magazine: Ben Zale, Editor; Lloyd E. Varden, Scientific-Technical Editor; David B. Eisendrath, Jr., Technical Editor. All contest entries will be sent to this board for judging, and the winners reported after each monthly closing date.

Photocopy Contest

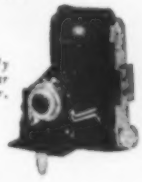
1st Prize—Ikoflex IIa
A truly fine reflex camera with Zeiss Opton coated Tessar f/3.5 lens, in Synchro Compur fully synchronized shutter. Speeds from 1 to 1/500 sec.

1st Prize Contessa 35
An outstanding 35 mm camera with 3 mm Zeiss Opton coated Tessar f/2.8 lens. Automatically focused by a built-in combined view and range-finder. Has built-in photo-electric exposure meter. Synchro Compur shutter is fully synchronized. Speeds from 1 to 1/500 sec.

2nd Prize Ikoflex Ia
Easily the finest reflex camera in its price class. Has Novar f/3.5 coated lens in a fully synchronized Prontor SV shutter with speeds from 1 to 1/300 sec.

2nd Prize Contina I 35
A superior 35 mm camera with Zeiss Opton coated Tessar f/2.8 lens, with optical range finder. Has fully synchronized Synchro Compur shutter. Speeds from 1 to 1/500 sec.

3rd Prize Nettar IIc
An excellent camera with extremely rigid construction. Comes with a Novar f/6.3 coated lens in Vario shutter. Flash synchronization at 1/25 sec.



THE ZEISS IKON CAMERA

Based on 90 years' tradition of fine camera manufacture, Zeiss Ikon cameras are recognized as symbols of photographic excellence throughout the world. Whether you are professionally interested, an amateur enthusiast or a snapshot photographer, a fine Zeiss Ikon camera will give you a lifetime of photographic pleasure. For those of you who have never taken many photographs, there is no better introduction to its enjoyments than a truly superior Zeiss Ikon product.

All Zeiss Ikon cameras are made in the U. S. Zone, Stuttgart, Western Germany.

All prices shown are national retail list prices, federal tax included, from the latest Zeiss Ikon price list published August 15, 1953.

YOUR REPORT IS A VALUABLE CONTRIBUTION TO THE INDUSTRY

We are planning to publish the winning reports as a portfolio of modern photocopy practices. The purpose of this portfolio will be to show how valuable photocopy is as an industrial tool, and as evidence of what is being done by experts in the field. No report will be published in the portfolio, or used in any other advertising or promotional material without your written permission and that of the company involved.

CONTEST RULES

1. Write a report on what you feel is an important use of photocopy in your company. You can send in as many reports as you want; however, you can win only once. If you have more than one report to submit, your best chance of winning a major prize is to space your entries in different contest months.

2. Be sure to include your name, position and company name and address on the report.

3. If you are a winner, you will be notified by mail. For 1st or 2nd prize winners you have your choice of the cameras listed; sent either to your home or office.

4. Please pay particular attention to the contest closing dates. No entry can be judged which is postmarked later than December 10, 1953.

5. All entries become the property of Peerless Photo Products, Inc. The decision of the judges is final.

6. The contest is open to everyone actively interested in industrial photocopy with the exception of employees and distributors of Peerless Photo Products, Inc.

PEERLESS PRODUCTS

Peerless is one major manufacturer in the field whose production and development facilities are devoted exclusively to industrial, scientific and commercial photo-reproduction. The entire Peerless line of photocopy papers and machines is sold only through a network of factory distributors who are skilled photocopy specialists. Complete literature on all Peerless products is yours for the asking.

DON'T DELAY!

Send your report to:

PEERLESS PHOTO PRODUCTS, INC.

Shoreham, Long Island, N. Y.

Manufacturers of quality Photocopy Papers and special-purpose Industrial Photocopy Equipment

10 GRAMIX® BEARINGS help the remarkable new REVERE TAPE RECORDER provide realistic tone

Listening to the new Revere Tape Recorder is a rewarding experience because each sound, every musical note is reproduced with amazing fidelity. This exceptional tonal quality is to a great degree made possible by the GRAMIX bearings on all rotating parts. GRAMIX bearings also simplify operation of the automatic key controls that start, stop and play the recorder at the slightest touch. And GRAMIX bearings on the new Index Counter make it possible to catalog any part of a recorded reel for easy, instant selection. GRAMIX bearings and other parts are compacted from powdered metals under pressures up to 70,000 psi., and sintered in high temperature furnaces. They can be produced in relatively complicated shapes to tolerances as close as .0003". They need little or no machining, thus virtually eliminating scrap loss and waste. Their porous structure saves metal and makes it possible to oil-impregnate the bearings during manufacture for self-lubrication. GRAMIX parts are strong and tough and will usually outperform and outlast similar machined parts for only a fraction of the cost. Chances are GRAMIX parts can improve the performance of your products and reduce your costs considerably. *Write today for your copy of our big, new* GRAMIX *catalog.*

96

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

Cutaway shows compact interior design and construction of a typical Cleveland worm gear speed reducer, used in thousands of plants. Clevelands save floor space—are simple to install and maintain. A minimum number of moving parts practically eliminates trouble.

Why WORM gear? Why CLEVELAND?

HERE are some of the inside reasons why Cleveland worm gear speed reducers are specified by many of the leading builders and users of industrial machinery.

• **SAFE, SPACE-SAVING, RIGHT-ANGLE DRIVE**—Clevelands are compact, provide a wide range of reduction speeds. Worm and gear enclosed in sealed housing replace dangerous open gearing, belts and pulleys. Safety always for machine operators and lube men! Gearing runs in oil bath, insures positive lubrication, eliminates oil cans and grease paddles.

• **SMOOTH TORQUE FLOW**—By virtue of the sliding action of worm on gear, a Cleveland transmits power uniformly and smoothly. Constant angular velocity assures positive control of work on driven machine.

• **LONG-LIFE EFFICIENCY**—Experience demonstrates that Cleveland case-hardened worms and nickel-bronze gears actually improve with use. Even operating under continued, severe overloads, danger of sudden failure is remote. Thousands of Clevelands operate for the life of driven machines.

Get the complete Cleveland story by writing for new Catalog 400 today. The Cleveland Worm & Gear Company, 3279 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

LORD ... Supplier to THE AUTOMOTIVE AND AVIATION INDUSTRIES for 25 Years...

LORD Mounts have become a vital part of the Automotive and Aviation Industries during the past quarter century. The vast reservoir of experience as a prime supplier is of great practical value to design engineers of today. Thousands of Lord Mounts protect the most sensitive instruments and the most rugged of component parts from shock and vibration.

Shown here are a few typical Lord applications used in wide diversity in the industry. We welcome the opportunity to help you with your shock and vibration problems.

BURBANK, CALIFORNIA 233 South Third Street
DALLAS, TEXAS 413 Fidelity Union Life Building
PHILADELPHIA 7, PENNSYLVANIA 725 Widener Building
DAYTON 2, OHIO 410 West First Street
DETROIT 2, MICHIGAN 311 Curtis Building
NEW YORK 16, NEW YORK 280 Madison Avenue
CHICAGO 11, ILLINOIS 520 N. Michigan Ave. Room 811 Hanna Building
CLEVELAND 15, OHIO

LORD MANUFACTURING COMPANY • ERIE, PA.

LORD BONDED RUBBER

Headquarters for VIBRATION CONTROL

Lord Bonded-Rubber Products Set Standard In Vibration and Shock Control For Over Twenty-Five Years

In the field of technical analysis and engineering to "design out" destructive factors set up in the machines of industry by vibration and shock, Lord Manufacturing Company continues to pioneer and set the pace for precision made vibration control mountings and bonded-rubber parts.

Years of experience in mounting aircraft engines and airframe components enable Lord Engineers to help industrial equipment designers in obtaining smoother operation, longer service life and increased safety in their machines.

Lord Engineers draw from some 27,000 basic designs and their variations to solve many vibration and shock problems referred to them by machine designers. Add to this the continuous research engineering available from the company's complete laboratories, and it becomes a matter of near impossibility to present a vibration problem which cannot find soluton in the Lord Organization. The scope of Lord Design and Precision Manufacture covers Vibration Control Mountings for aircraft engines and components in both the internal combustion and jet field, delicately balanced and precisely assembled units of accounting machines, electronic equipment, instrument panel mountings, shipping case mountings for the protection of sensitive machines in transit.

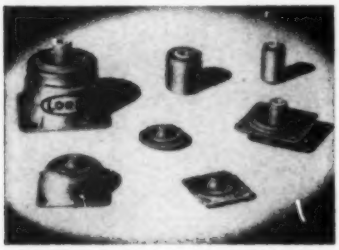
Designers of home appliances use Lord bonded-rubber parts for fan-hubs, flexible couplings and special components for washing machines, room air conditioners, mixing and juicing devices. Lord Flexible Couplings are used in the mechanism which operates motorcar windows and convertible tops. The turbine engine for heavy duty motor truck transport, a recent development of the Boeing Airplane Company, is connected to the power transmission by a special Lord Flexible Coupling and the engine itself is supported on Lord Mounts. Lord Engineering and Precision Manufacturing facilities are available to business and industry wherever Vibration and Shock Isolation problems require a precise, accurate and inexpensive solution.

(ADVERTISEMENT)

Lord Vibration Control Mountings . . . The Most Effective Protection For Electronic Equipment

In the rapidly advancing field of electronics, the control of destructive vibration and isolation of damaging shock are prime factors in the consideration of design engineers. Lord, Headquarters for Vibration Control, is constantly working with electronics engineers to improve the methods for protecting sensitive mechanisms.

For instance, Varo Static Converters which change alternating to direct current for aircraft with less than 1% voltage ripple are protected against shock and vibration by Lord Mountings. High fidelity Audio frequency electronic equipment such as Collins Radio Company manufactures is protected from vibration and shock through the use of Lord Mountings. The 212A-1 Broadcast Station Speech Input Console by Collins requires 28 Lord square Plate Form Mountings to protect each amplifier stage individually. This prevents mechanical interaction between stages and lessens acoustical feed-back effects.

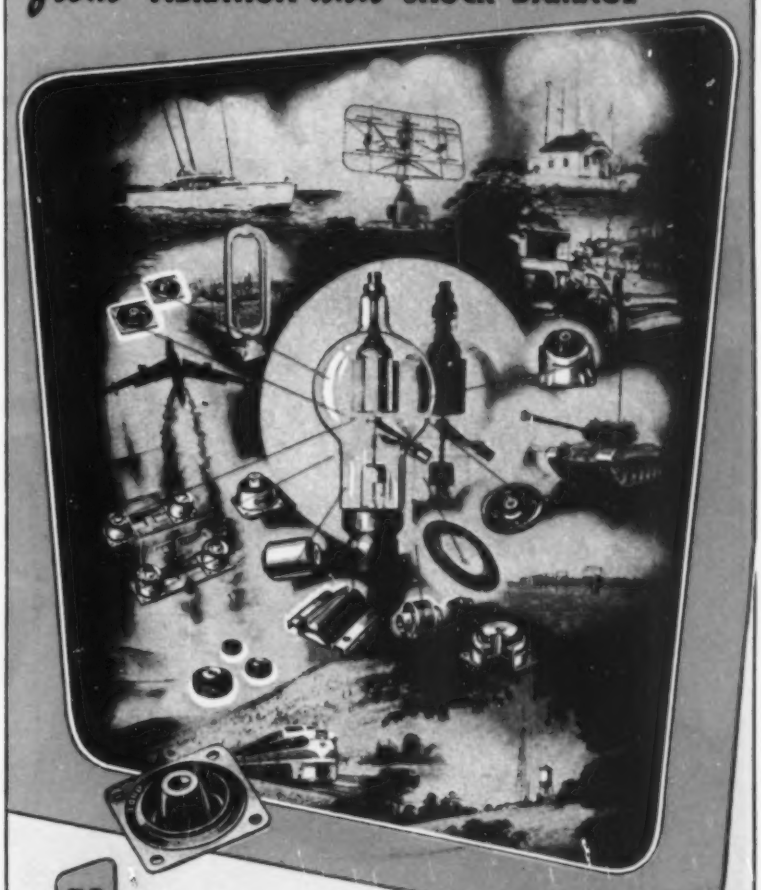


Again the Agnew Spark Plug Welder by Agnew Electric Company uses Lord Mountings to support the electronic weld timers to prolong the useful service life of Mercury Vapor Tubes.

Lord Mountings, which you see illustrated in the accompanying advertisement, are used in a wide diversity of applications to protect electronic equipment and sensitive instruments. Business machines and such sensitive mechanisms, the accuracy of which must be perfect, are improved in operation and protected from damaging vibration and shock by Lord Mountings.

The Lord Manufacturing Company, Erie, Pa., offers a vast reservoir of recorded experience in the solution of vibration and shock problems. Your request for help on your own problem is welcomed.

LORD MOUNTINGS PROTECT INSTRUMENTS *and* ELECTRONIC EQUIPMENT *from* VIBRATION *and* SHOCK DAMAGE • • •



VIBRATION and shock are natural enemies of electronic equipment and precision instruments . . . To control the damage which these enemies can do, Lord Vibration Control Mountings and Bonded Rubber Parts are used to very profitable advantage. More than a quarter century's experience in dealing with vibration and shock is yours when you take advantage of Lord engineering assistance. The result of such consultation is full protection for electronic units and sensitive instruments by correctly designed and precisely manufactured Lord Mountings and Bonded-Rubber parts.

BURBANK, CALIFORNIA 233 South Third Street
DALLAS, TEXAS 413 Fidelity Union Life Building
PHILADELPHIA 7, PENNSYLVANIA 725 Widener Building
DAYTON 2, OHIO 410 West First Street
DETROIT 2, MICHIGAN 311 Curtis Building
NEW YORK 16, NEW YORK 280 Madison Avenue
CHICAGO 11, ILLINOIS 520 N. Michigan Ave. Room 811 Hanna Building
CLEVELAND 15, OHIO

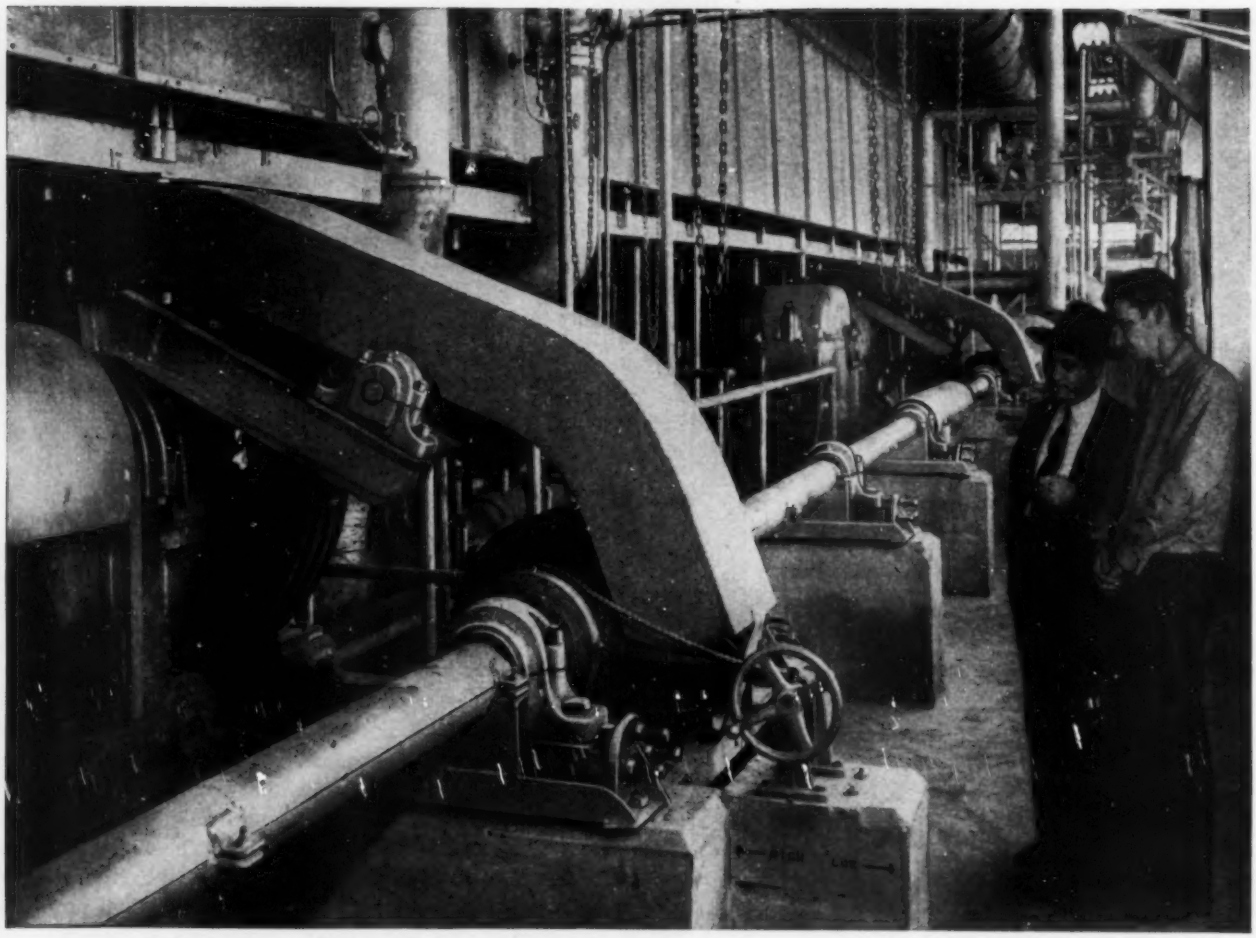
LORD MANUFACTURING COMPANY • ERIE, PA.

LORD BONDED RUBBER

Headquarters for **VIBRATION CONTROL**

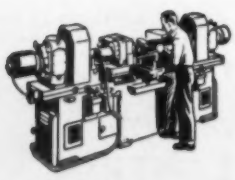
LINK-BELT ball and

...keep company with



Link-Belt Roller Bearing Pillow Blocks assure smooth power transmission under varying atmospheric operating conditions. That's one reason why Downingtown Manufacturing Company used them on the main line shafts and variable speed drives of their felt making cylinder machine shown in service at The Ruberoid Company, Mobile, Ala.

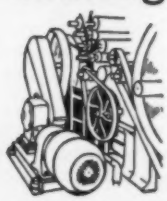
LINK-BELT ball and roller bearings



Metal Working Machinery

Farm Machinery

Construction Equipment



Textile Machines

roller bearings

America's hardest-working machines

The efficiency and life of any machine are dependent on the quality and accuracy of its bearings. That's why so many equipment designers specify Link-Belt on their heaviest-duty machines.

Link-Belt precision Ball and Roller Bearings have proved—on thousands of applications—that they are the long-life answer for tough service. Integrally self-aligned, they have full load capacity for both thrust and radial loads.

There are Link-Belt ball or roller bearings to meet every industrial need, and a Link-Belt bearing specialist near you will help apply them to your particular requirements. You can also get all the facts from Data Book 2550.

CUTAWAY OF SERIES 6800-6900
TWO-PIECE ROLLER BEARING PILLOW BLOCK
Self-aligning—inner raceway is truly spherical, free to move in any direction without altering contact area with rollers. Full load capacity always assured even with shaft deflection or misalignment.
Jack screw holes are provided for easy removal of housing cap.
Tapered adapter sleeve provides positive concentric mounting on commercial shafting.
Large reservoir prolongs lubrication intervals.
Easily installed by removing housing cap, slipping adapter assembly onto shaft and locking in position.
Sturdy, two-piece cast housing facilitates installation, inspection and disassembly.
Seals effectively keep lubricant in, dirt out.
"Housing sealing" feature fully protects and lubricates all moving surfaces.
Slotted bolt holes facilitate mounting on supporting structure.

One of many types in the Link-Belt line of Pillow Blocks, Flanged, Flanged Cartridge, Cartridge, Hanger, Take-Up Blocks and Unmounted Bearings.

LINK-BELT

BALL and ROLLER BEARINGS

13.274

LINK-BELT COMPANY: Plants: Indianapolis, Chicago, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle; Scarboro, Toronto and Elmira, Ont. (Canada); Springs (South Africa); Sydney (Australia). Sales Offices, Factory Branch Stores and Distributors in Principal Cities.

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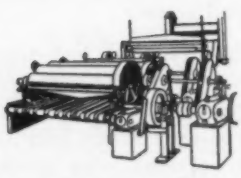
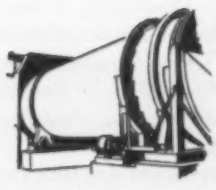
smooth the path of power for all industry



Pulp & Paper Machinery

Materials Handling Equipment

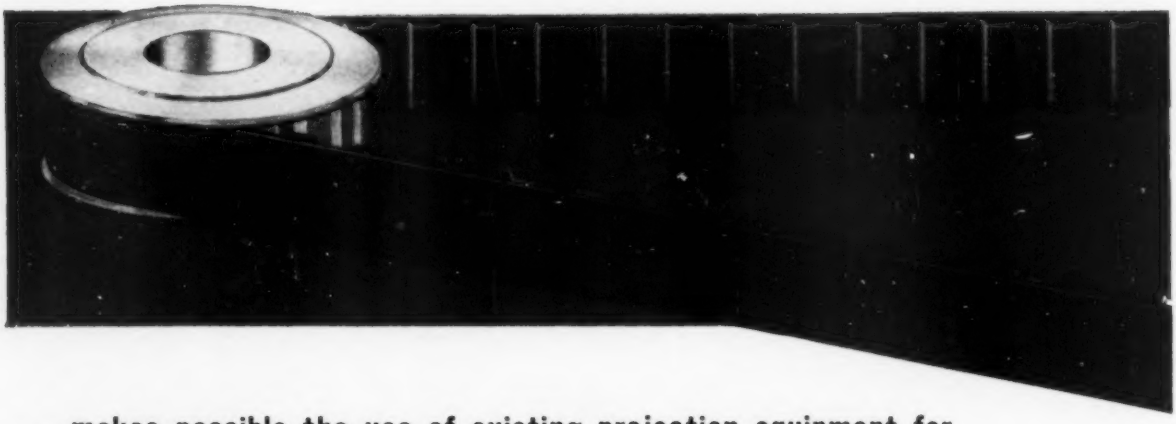
Oil Field Equipment



Processing Equipment

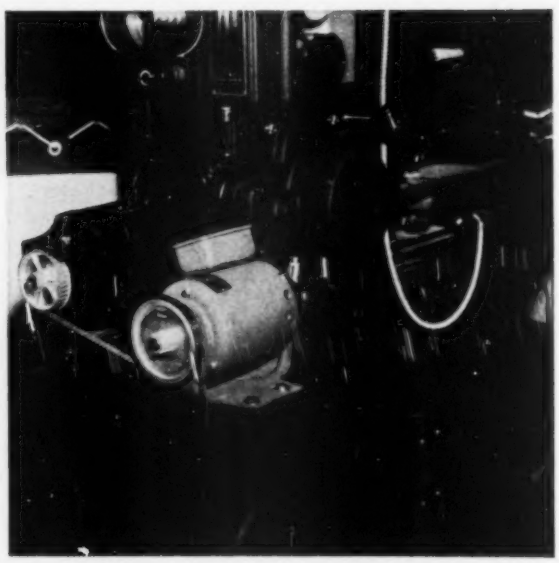
Here's How the Revolutionary

Gilmer "TIMING"®



. . . makes possible the use of existing projection equipment for

3-D MOTION PICTURES



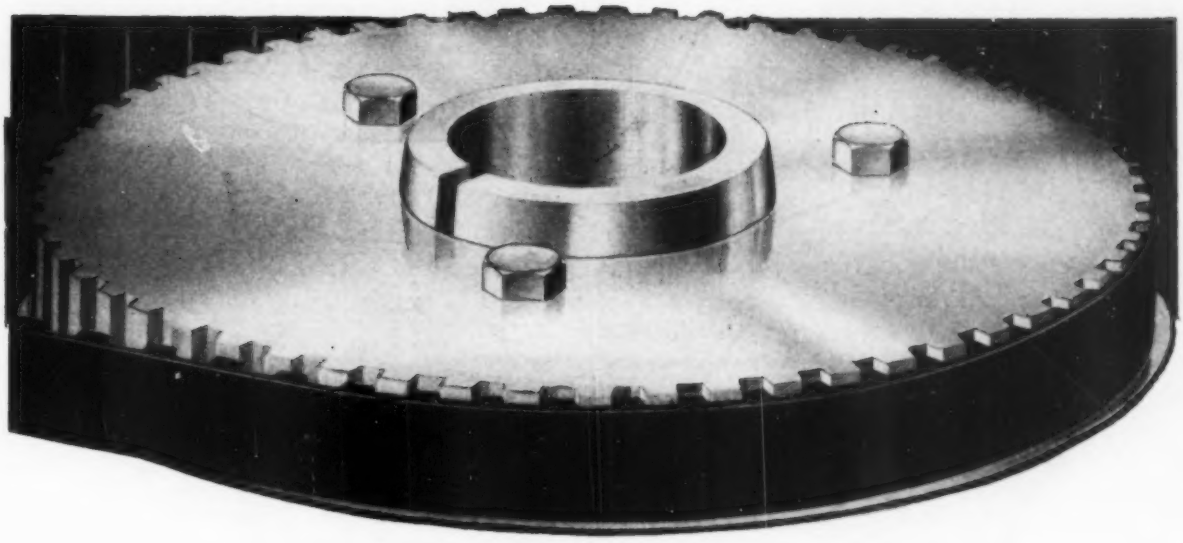
STEREOSCOPIC pictures and stereophonic sound are rapidly replacing conventional movies in hundreds of theaters across the country. Significantly, no conventional type of drive has proved as satisfactory as the Gilmer "Timing" Belt drive in the all-important job of synchronizing the multiple projectors and sound tracks required by the various 3-D systems.

A typical installation is shown. This system permits use of two conventional projectors, simultaneously projecting oppositely-polarized versions of the same picture. Each projector is equipped with an added Selsyn motor connected to the regular motor by a "Timing" Belt drive. The two Selsyn (self-synchronizing) motors, each electrically connected to the other, serve as braking or accelerating controls to maintain perfect frame-for-frame synchronization between the projectors.

Obviously, to maintain such accuracy, there must be no appreciable backlash in the interlock drives. The "Timing" Belt drive has proved most satisfactory, and has been generally adopted, in this application because it remains free of backlash indefinitely, does not become "sloppy" with use, requires no lubrication or cover, can be quickly replaced, runs silently and operates in any plane regardless of projector tilt. It also maintains constant angular velocity, cannot cause flutter in the picture or "wow" in the sound system.

These characteristics of the "Timing" Belt drive have also made it the choice of manufacturers of stereophonic sound systems to synchronize the multiple magnetic tape reproducers which feed the several speakers located at opposite sides of the screen.

BELT DRIVE



Industry's New Power Transmitting Medium
SWEEPS AWAY DESIGN RESTRICTIONS

In one application after another, "Timing" Belt Drives have enabled machine designers to achieve basic engineering improvements—or to design entirely new machines—that were previously either impractical or impossible! For never before has there been a *positive drive* that combined all these desirable characteristics:

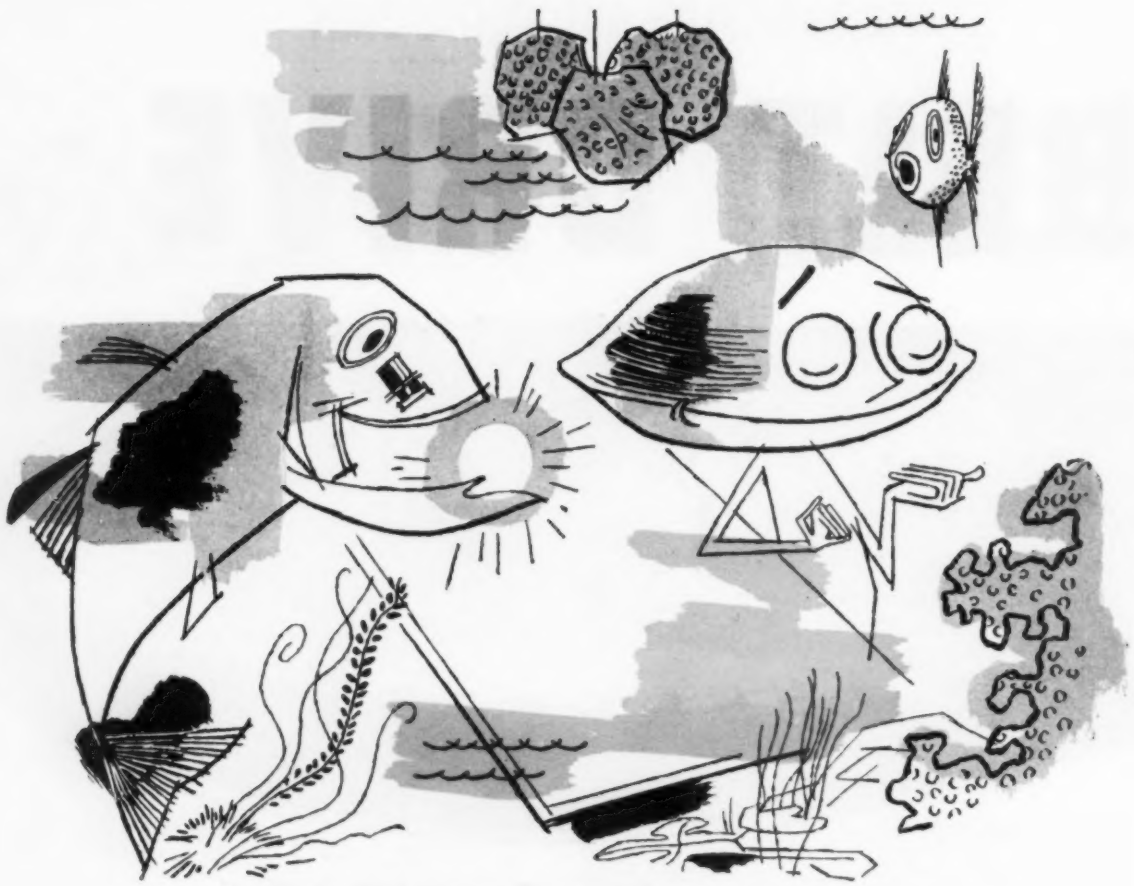
- **Requires no lubrication, no housings or lubricant guards.**
- **Maintains precise synchronization ("timing") between shafts.**
- **Provides speed ratios as high as 15 to 1 in a single step.**
- **Operates satisfactorily at speeds from inches per hour to 15,000 fpm.**
- **Permits use of very small diameter pulleys for ultra-compact drives.**
- **Has nearly 100% mechanical efficiency.**
- **Needs no initial tension. Lighter bearing loads permit lighter bearings.**
- **Does not stretch or lengthen with use; requires no take-up.**
- **Can be designed for zero backlash.**
- **Capacity ranges from 1/100 to 300 horsepower.**

These are but a few of the unique features of this amazing tooth-grip belt drive that is already in successful use on hundreds of thousands of machines. Consult your local NYB&P Distributor—or write direct—for the new "Timing" Belt brochure describing in more detail the "Timing" Belt and many interesting applications. Address: "Timing" Belt Division, New York Belting & Packing Co., Tacony, Philadelphia 35, Pa.

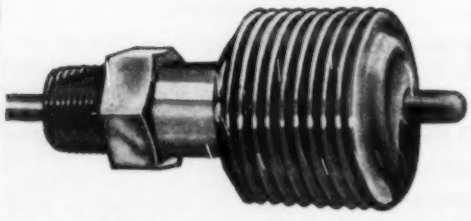
NYB&P — NEW YORK BELTING & PACKING CO. — Founded 1846

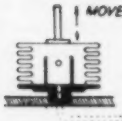
NEW YORK BELTING & PACKING CO. 1 Market St., Passaic, N. J.

America's Oldest Manufacturer of Industrial Rubber Products



ONLY A SPECIALIST CAN DO IT RIGHT!





MOVEMENT

Thermostatic Motor—This type of assembly is widely used in temperature regulators, etc., where a thermostatic charge is confined in the bellows and where a valve, switch, damper, etc. is to be operated in response to temperature changes.

● Take bellows assemblies, for example. Designing and producing them is a specialty at Fulton Sylphon and Bridgeport Thermostat. Has been for over a half-a-century. So it's only natural that so many users of bellows assemblies come to us.

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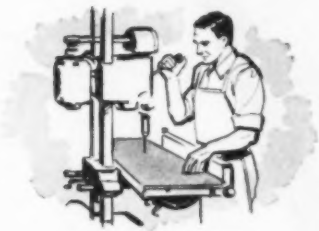
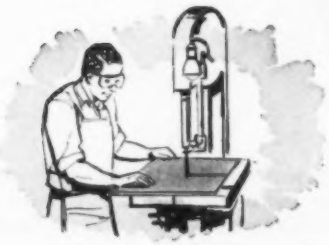


Drilling and punching



Sawing and shearing

Welding on reverse side

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Investigate Du Pont vitreous enamel for aluminum. It's a practical way to make your product look better, wear longer and sell faster. Send the coupon below for details. We'll be glad to supply you with technical literature and give you specific recommendations on how the enameling process can best be adapted to your individual needs. And, at your request, we can also put you in touch with enamelers who are completely familiar with the vitreous enamel process.

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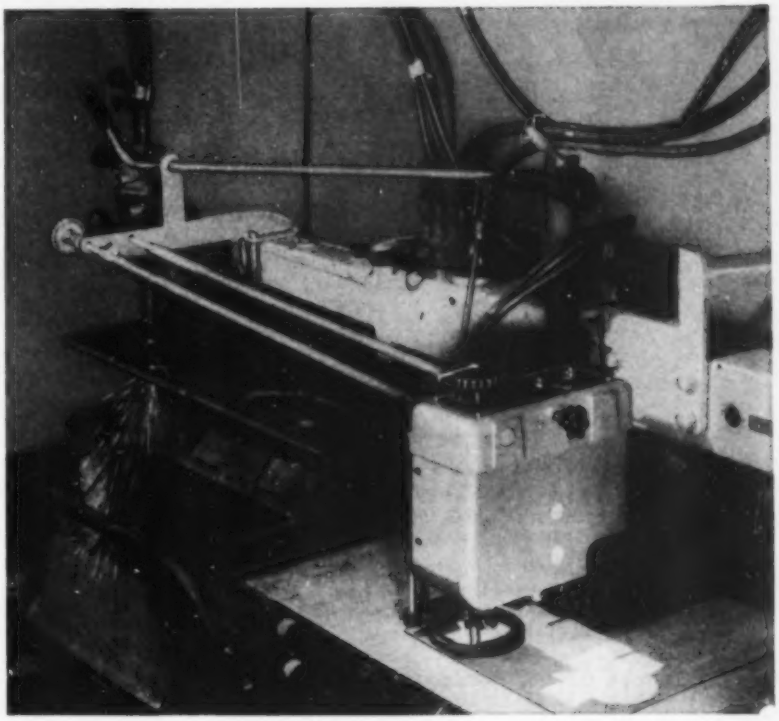

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That's how Edison sums up its ultra-modern, individual dictating instrument, the "V.P."

Small compact, soundly engineered and outstandingly handsome, this pint-sized prodigy provides an important aid for those engaged in business, science, education, and other fields.

Says the Director of Engineering for the Ediphone Division: "The development and design of this new concept in dictating machines, resulting in the smallest and lightest produced, was possible only thru the use of many die castings. Their high strength-to-weight ratio; great flexibility of shape, permitting maximum utilization of space; inherent reproducibility; and low cost, *cannot be matched by any other* structural means."

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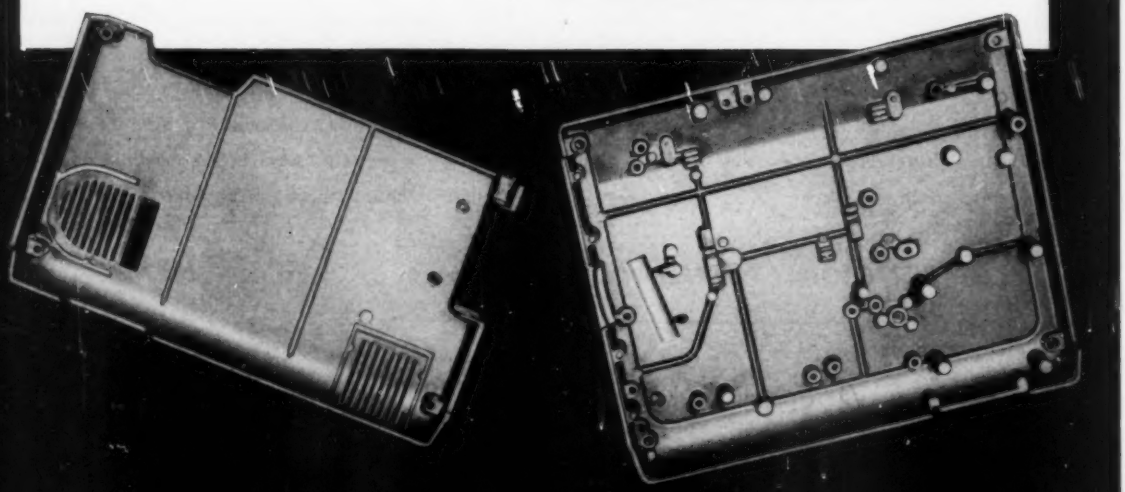

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THE ONLY SAFETY SWITCH IN SPECIAL INDUSTRY ENCLOSURE!

CAPTIVE SCREWS assure tight cover fit

EXTERNAL MOUNTING FEET eliminate need for conventional leaky mounting holes within the enclosure

NEOPRENE GASKET provides positive cover seal

WELDED TIGHT ENCLOSURE without knockouts excludes dirt, dust, oil, and splashing coolant

This new heavy duty switch, built to NEMA XII specifications, is "tailor-made" for applications requiring the exclusion of dirt, dust, oil and coolant.

The rugged, visible-blade switch mechanism within the special industry enclosure has all the performance features that have made Square D an overwhelming "first choice" for fifty years.

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helps put the *punch* in
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HERE'S the plant that powers new super jets—one of the most powerful jet engines ever released for production!

Look closely and note the broad application of tubular wire braid. It is typical of many types and sizes regularly produced by National-Standard for aircraft service—used not only for electrical shielding, but to reinforce thermocouple harness leads, as shown.

National-Standard with the largest range of wire braiding equipment in the country, is well prepared to supply or develop special braid that will meet your needs *exactly!*

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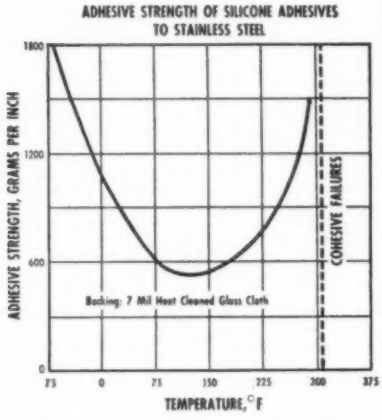
DOW CORNING **Silicone News**

Vol. I, Number 1 • PUBLISHED BY DOW CORNING CORPORATION, MIDLAND, MICHIGAN

New Pressure Sensitive Silicone Adhesives Stick To Most Surfaces; Retain Their Excellent Adhesive Strength From -55F To Over 250F

The newest products to come out of our development laboratories are pressure sensitive silicone adhesives that stick to almost any materials including silicones and Teflon. Adhesive strengths in the range of 1800 grams per inch at —55 F and over 1200 grams per inch at 265 F, are far superior to those of conventional pressure sensitive tapes. The adhesive strength between a stainless steel surface and glass tape coated with silicone adhesives is plotted against temperatures ranging from —75 to 285 F in this Figure.



Uses for tapes coated with silicone adhesives include high temperature electrical and electronic applications; weather and moisture resistant wrapping and sealing tapes for low temperature applications. One electrical equipment manufacturer is already using these pressure sensitive adhesives to bond mica matt and integrated mica to glass cloth. *No. 1*

Silicone-based Aluminum Paints Outlast Organic Finishes 10 to 1 at Sterilizing Temperatures

Trays containing vials of aureomycin and other antibiotics at the Lederle Laboratories Division of American Cyanamid Company are loaded onto racks and sterilized for 3 hours at 446 F to destroy pyrogens.

The organic aluminum finish on these racks began to crack and peel, permitting rust to form, after 9 to 15

(continued page 2)

Flexible Silastic* Tubes Carry Air at 500 F; Prevent Engine Failure Due to Icing Over Jet Air Scoops

Reinforced with stainless steel braid, Silastic tubing requires minimum space; endures heat and high frequency vibration.

It was discovered shortly after certain jet engines were put into service that the formation of ice over air intake scoops could choke off the air supply and cause engine failure.

The obvious solution to this problem was to pipe air at 500 F from the compressor to the scoops. But that simple solution involved many problems.

The jet engines were so tightly fitted in their nacelles, that very little room was left for hot air ducts of any kind. High frequency vibration set up by the engine and plane introduced the problem of fatigue failure.

This was a job for a flexible tubing, a tubing that could carry hot air without melting, withstand the vibration and permit fast and easy assembly and disassembly. Engineers of the Aeroquip Corporation of Jackson, Michigan, solved the problem with flexible Silastic tubing. Reinforced with stainless steel braid, Silastic tubing is light and flexible. It is held mechanically to the stainless steel braid so tightly that the tube will not collapse even when subjected to a vacuum.

The high temperature problem of attaching a fitting to the hose was ingeniously solved by the new Aeroquip "Little Gem" fittings. The total assembly proved to be so effective that these anti-icing hoses have become standard equipment.

Despite internal and external temperatures as high as 500 F, the Silastic hoses are still in excellent condition after hundreds of hours of service. Aeroquip has supplied thousands of them to jet manufacturers. From 5 to 20 are required per engine, depending upon its design.

The usefulness of Silastic in this application confirms data collected by our development engineers on effects of accelerated aging at high temperatures on the properties of Silastic. Heat resistant organic rubber becomes brittle in a few hours; Silastic 80 does not crack on flexing over a ⅜ inch mandrel, and hardness increases only 9 points after more than 670 hours of continuous aging with all surfaces of the test sample exposed in an air circulating oven at 480 F.

Silastic 80 readily meets SAE-ASTM Specification TA805 which requires that it have a minimum tensile strength of 500 psi; a minimum ultimate elongation of 50 percent. After 70 hours aging in an air oven at 450 F, increase in hardness is not more than 15 points; drop in tensile strength is less than 25 percent and loss of ultimate elongation, less than 40 percent.

In oil resistance tests, decrease in hardness is less than 45 points; increase in volume, less than 60 percent after 70 hours immersion in ASTM No. 3 oil at 300 F. After 70 hours immersion in ASTM No. 1 oil at 300 F, loss in tensile strength and ultimate elongation is less than 20 percent; decrease in hardness,

(continued page 2)

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DOW CORNING SILICONE NEWS PUBLISHED BY DOW CORNING CORPORATION

NEW DEVELOPMENT AND TECHNICAL DATA

For copies of any of the publications reviewed in this column or for data relating to any of the articles printed in this issue of the Dow Corning Silicone News, simply circle the corresponding reference number on the coupon below.

Expansible resins. Two new silicone resins, Dow Corning XR-543 and XR-544, can be expanded to produce heat-stable, non-flammable, unicellular foams with densities from 8 to 24 lbs per cubic foot. Highly resistant to thermal shock, these silicone foams show practically no structural or dimensional change after 20 hours at 700 F. Weight loss after 220 hours at 570 F is less than 2%; moisture absorption less than 0.05% after 7 days at 96% RH. Resins are easily foamed in place, made up as sandwich structures or machined with wood working tools. *No. 5*

•

Dow Corning 1109, a durable new silicone water repellent treatment for leather footwear, gloves, luggage and sporting goods; minimizes water absorption and transmission; improves resistance to oils and chemicals without changing the "breathing" characteristics of leather. *No. 6*

•

Now available, the new 1953-54 Reference Guide to Dow Corning Silicone Products summarizes properties and applications for commercially available silicones. A complete revision of previous guide which some designers have reported to be one of the most helpful catalogs ever produced. *No. 7*

•

Silastic 6-127 paste, an excellent cloth coating material and bonding agent for silicone rubber, retains good dielectric properties over a wide range of temperatures and frequencies. It has superior resistance to heat and moisture; remains flexible down to — 100 F. *No. 8*

•

"Tall Tales and Fabulous Facts" is a new 24 page booklet built around the idea that, in our times, the tallest tales are told in technical terms. In this publication, the tall tales our ancestors told about such legendary characters as Paul Bunyan, Davy Crockett and Pecos Bill are related to some equally fabulous facts about Dow Corning silicone products. *No. 9*

•

Air drying silicone water repellent for application to glass, plastic and ceramic insulator bodies and to electronic parts and components maintains high surface resistivity under humid conditions; minimizes adhesion of dirt and chemical dust; reduces maintenance. *No. 10*

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Small Electric Machines and Electronic Parts Can Now Be Designed to Operate at 180 C.

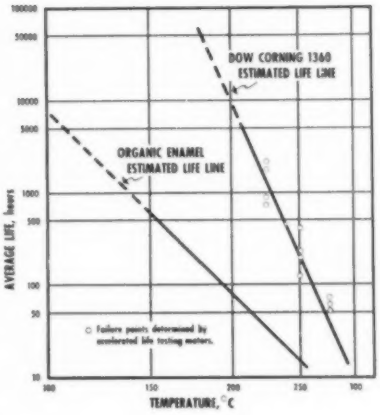
Life and reliability can be increased, or the size and weight of electronic devices and fractional or miniature motors can be reduced through the use of bare magnet wire insulated with Dow Corning 1360 Wire Enamel

Flexibility, scrape hardness and dielectric strength compare favorably with those of the best organic wire enamels. Dow Corning 1360 coated wire also shows superior resistance to a wide variety of solvents, oils and salt water.

The results to date of the accelerated life testing at temperatures in the range of 200 to 275 C of several electric motors wound according to standard commercial procedures with 1360 coated wire are plotted in the chart at right.

These data show that motors wound with magnet wire insulated with Dow Corning 1360 Wire Enamel have a life in the range of 1500 hours at 225 C (437 F), compared with 30 hours for identical motors wound with the best grade of Class A wire.

Based on the results to date of this motor test program, we expect that the



life of machines wound with 1360 coated wire at 180 C will be comparable to that of identical machines wound with conventional Class A wire at their maximum operating temperature of 105 C.

Extrapolating from the data plotted above, we find that the life expectancy at 180 C of magnet wire insulated with this new enamel is in the range of 50,000 hours compared with 200 hours for wire insulated with the best organic enamels. *No. 4*

SILASTIC *continued*

less than 15 points. It shows no shrinkage and swell is less than 20 percent.

After 168 hours immersion in water at 158 F, swell is less than 10 percent and decrease in hardness is less than 10 points. It does not become brittle on continuous exposure at —65 F.

Silastic 80 offers another advantage in that it can be blended with Silastic 50 to fabricate parts having any Shore hardness between 50 and 80. These stocks can be blended to fabricate parts that meet SAE-ASTM Specification TA604. Heat-stable pigments can be used to give these stocks almost any desired color.

In electrical applications such as wire covering and cable coating, Silastic 80 retains excellent dielectric properties over a wide range of temperatures and frequencies. Cable insulated with Silastic 80 has a dielectric strength of 450 volts/mil at 50 C; 430 volts/mil at 250 C. *No. 3*

PAINTS *continued*

hours of such service. That introduced a costly hazard because any bit of rust or paint chips in a tray could cause rejection of a whole rack of carefully prepared antibiotics.

Some time ago, the racks were sand blasted, sprayed with a silicone-based aluminum paint. So far, the silicone finished racks have endured 150 hours at sterilizing temperatures with no sign of deterioration. As a result of that experience, Lederle is now using silicone-based paint to refinish sterilizing equipment throughout their plant.

At temperatures in the range of 500 to 1000 F. silicone-based aluminum finishes are used to protect stacks, exhaust mufflers, dryers, and furnaces. Modified silicone enamels in a wide variety of colors are used to protect appliances such as stoves, space heaters and incinerators at temperatures in the range of 400 to 700 F. *No. 2*

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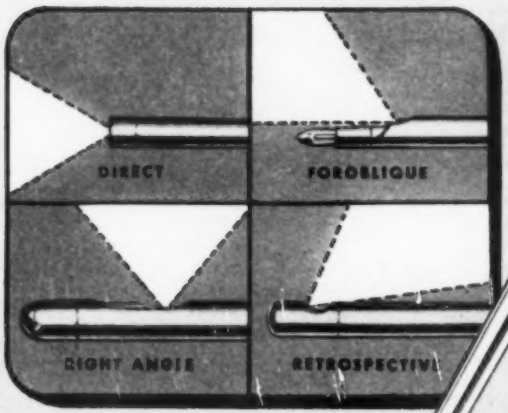

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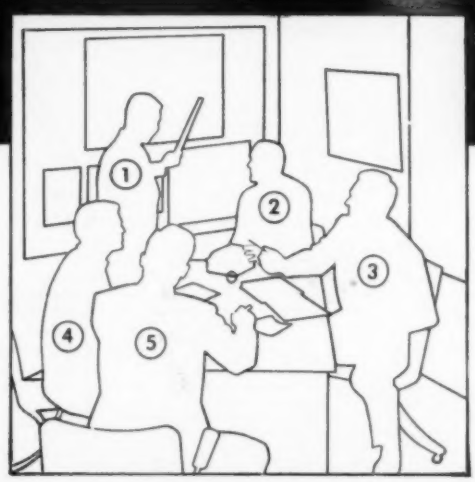

Your motor and control problems are local . . . so is Westinghouse application assistance

Do you put a full team on the field when you tackle a motor and control application problem? Are you cashing in on the know-how of your local staff of Westinghouse application engineers? Take a look at this line-up:

Your local Westinghouse sales engineer has a broad knowledge of all Westinghouse Motors and Controls. He knows their capabilities and limitations. He knows how to match motors and controls for maximum production.

Your local Westinghouse application engineer is equipped to analyze any motor and control problem and then develop the best solution. He can handle any application problem from a simple machine tool to a complete production line.

Your local Westinghouse product engineer is a specialist in one type of motor or control. These men work at the local level but operate from a manufacturing headquarters office.

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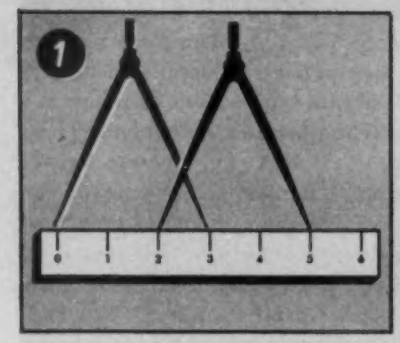
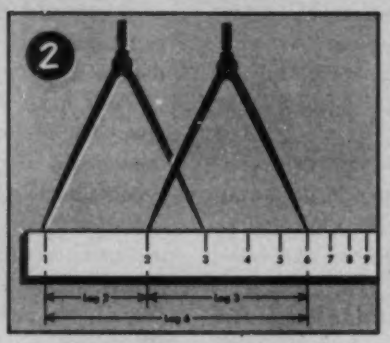
Pittsburgh 30, Pa.	ATlantic 1-8400
Portland 4, Ore.	CApitol 1-9151
Providence 3, R. I.	GAspee 1-0818
Raleigh, N. C.	6302
Reading, Pa.	2-0287
Richmond 19, Va.	2-4758
Roanoke 4, Va.	6263
Rochester 7, N. Y.	MOnroe 1635
Rockford, Ill.	2-3452
Rutland, Vt.	3292
Sacramento 14, Cal.	GIlbert 3-6525
Saginaw, Mich.	4-2640
St. Louis 1, Mo.	CEntral 1120
Salt Lake City 1, Utah	5-3413
San Antonio 5, Tex.	GArfield 5114
San Diego 1, Cal.	MAin 8151
San Francisco 8, Cal.	EXbrook 2-5353
Seattle 4, Wash.	MAin 0808
Shreveport, La.	4-5298
Sioux City 4, Iowa	5-7634
South Bend 4, Ind.	3-7167
Spokane 8, Wash.	MAin 3294
Springfield, Ill.	3-1532
Springfield 3, Mass.	6-8373
Syracuse 4, N. Y.	2-1361
Tacoma 2, Wash.	BRoadway 6565
Tampa 1, Fla.	2-7246
Toledo 4, Ohio	GArfield 4625
Trenton 10, N. J.	2-4136
Tulsa 3, Okla.	3-3191
Utica 1, N. Y.	4-1194
Walla Walla, Wash.	5124
Washington 6, D. C.	NAtional 8-8843
Waterloo, Iowa	4679
Watertown, N. Y.	1400
Wheeling, W. Va.	6222-6223
Wichita 2, Kansas	5-2631
Wilkes-Barre, Pa.	3-1144
Williamsport, Pa.	4289
Worcester 8, Mass.	4-2648
York, Pa.	7851
Youngstown 3, Ohio	4-1118

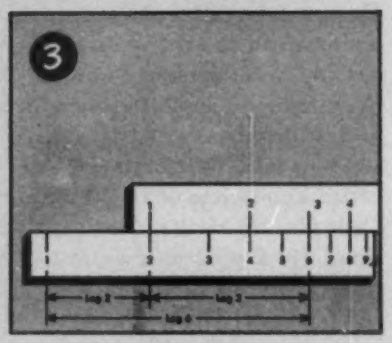
YOU CAN BE SURE...IF IT'S Westinghouse



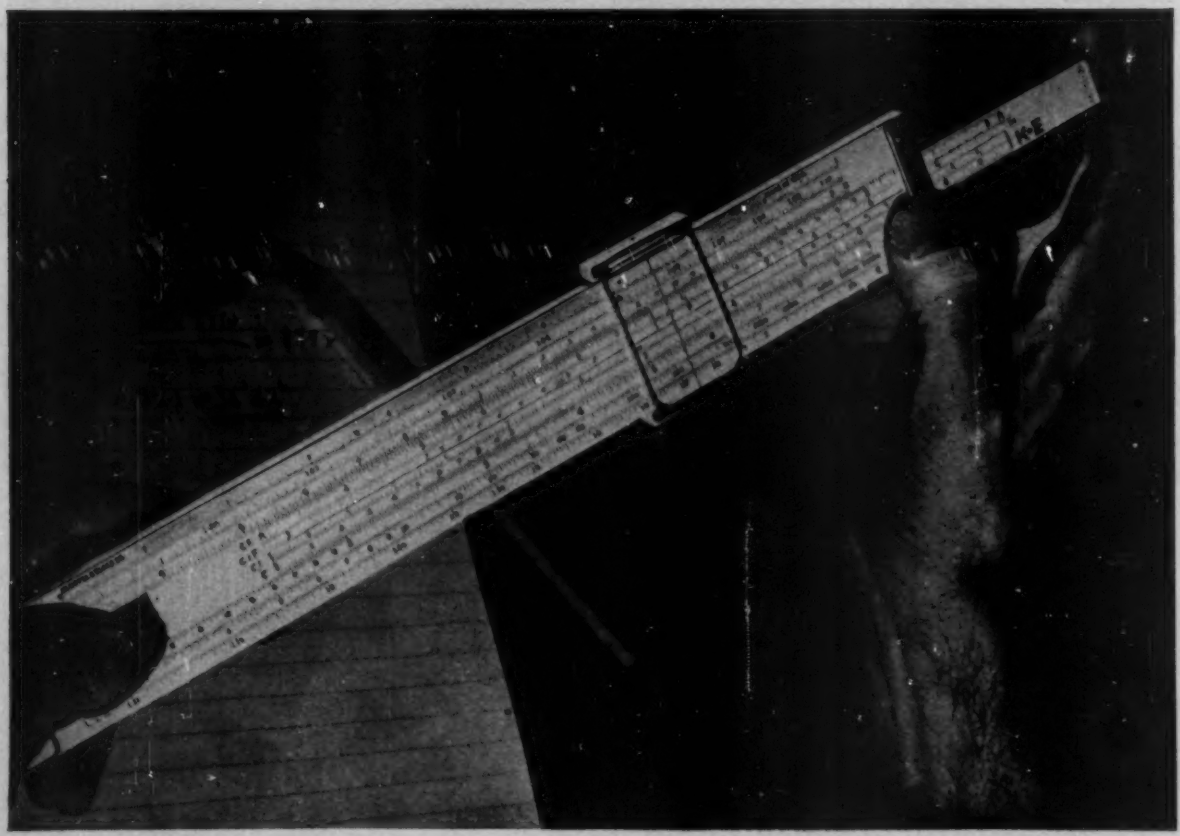
In a mechanical sense, the slide rule merely adds and subtracts quantities. How these simple operations can be performed mechanically may be seen from the illustration above, which shows the addition of 2 and 3 by means of a pair of dividers applied to an ordinary 6-inch rule. Even many electronic calculators work basically on this principle.

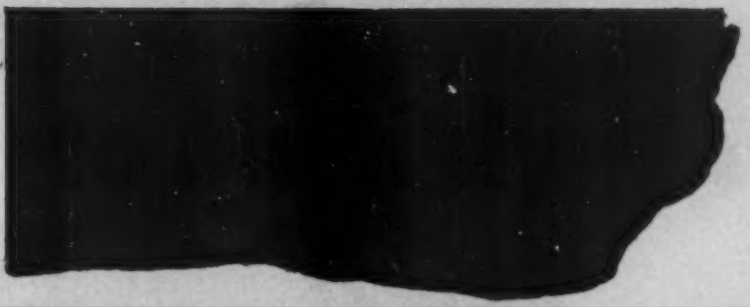


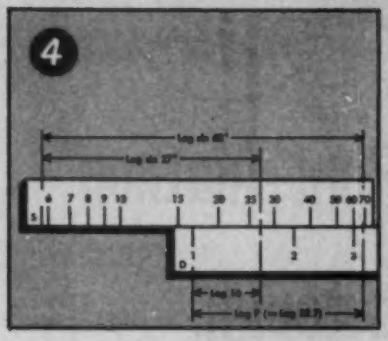
With a different system of calibrations on the scale, if appropriate meanings are assigned to them, more difficult problems may be solved in the same way. An example of this is seen above where a pair of dividers is shown adding 2 and 3 on a logarithmic scale and obtaining the answer 6. Advantage is taken of the fact that the multiplication of numbers may be accomplished by the addition of their logarithms.



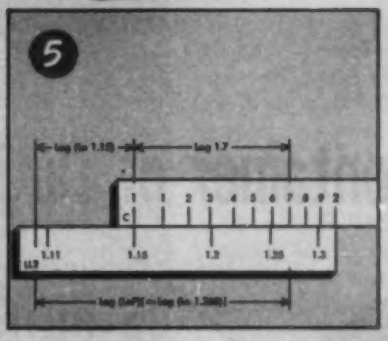
A handier method, which begins to approach the usefulness of a slide rule, is to place two similar logarithmic scales together. Seen above is the simple setting in which 2 is shown being multiplied by 3. Observing the illustration it can be seen that the same setting also multiplies 2 by 2 and 4. Without changing the setting, the device shows the corresponding operations in division.







Problems in plane trigonometry require only appropriate logarithmic scales, calibrated to read in degrees so that operations can be performed on the functions of angles. Two scales of this kind are generally used: one for the sines of angles and the other for tangents. Above is seen a setting for finding $P = \frac{16 \text{ Sin } 68°}{\text{Sin } 27°}$.



Problems of greater complexity, involving higher powers and roots of numbers, including fractional and negative powers and roots, can also be made as easy as 2 + 3 by means of appropriate logarithmic scales. Known as log log scales, they are calibrated to read in logarithms of logarithms. Above is seen a setting for finding $P = 1.15^{1.7}$.

The slide rule has been called the symbol of the engineer. The symbol that distinguishes the slide rule itself for leadership in design and workmanship is the K&E trade mark or the name KEUFFEL & ESSER CO.

Pioneers in the manufacture of slide rules in America, K&E have always been in the forefront with new ideas and improvements. The most recent example is the slide rule of today, the K&E Log Log Duplex Decitrig*, designed on the fundamental and simple principle of referring all its scales to the basic C-D scales. This enables problems involving arithmetic, trigonometric and exponential functions to be readily solved without reading any but the final answer.

Ask your K&E Distributor or Branch for full information about K&E Slide Rules.

The Right Angle

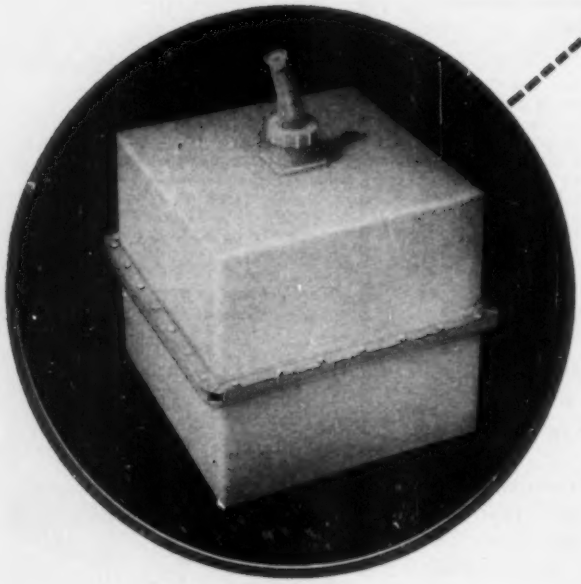
If you'd like l-o-n-g mileage without re-sharpening, get a PARAGON* RED TIP ruling pen. They are tipped with tungsten carbide alloy butt-welded to stainless steel blades. Ideal for use on aluminum, glass cloth and other abrasive surfaces as well as on regular paper or cloth. Identify it by the red tip at the end of the handle.

A good way to make life easier is to give your drawing board a glass-smooth, non-glare working surface with a covering of LAMINENE†. This drawing board backing material is washable, hard enough to minimize pencil scoring, but yielding enough for pencil lines to take well. Comes either white or green, in rolls.

*Trade Mark ®
†Trade Mark

K+E

New carboy container of Du Pont Alathon*



is light, tough, chemical-resistant

This new carboy offers improved utility and economy for the shipment and storage of corrosive chemicals. The 15-gallon inner container (complete with screw cap, seal and pouring spout) is molded of Du Pont "Alathon" polyethylene resin, yet weighs only 12 to 13 pounds. This saving in weight means easy handling, low shipping costs. The moldability of "Alathon" permits the square shape . . . means easy stacking and full use of shipping and storage space.

Du Pont "Alathon" has a low specific gravity (0.92) and exceptional resistance to chemical attack. "Alathon" is tough, resilient, virtually unbreakable—even at low temperatures. It contains no plasticizer . . . is non-contaminating. "Alathon" has a low rate of water-vapor transmission. And parts can be economically molded of "Alathon" by injection molding, cutting production time and costs.

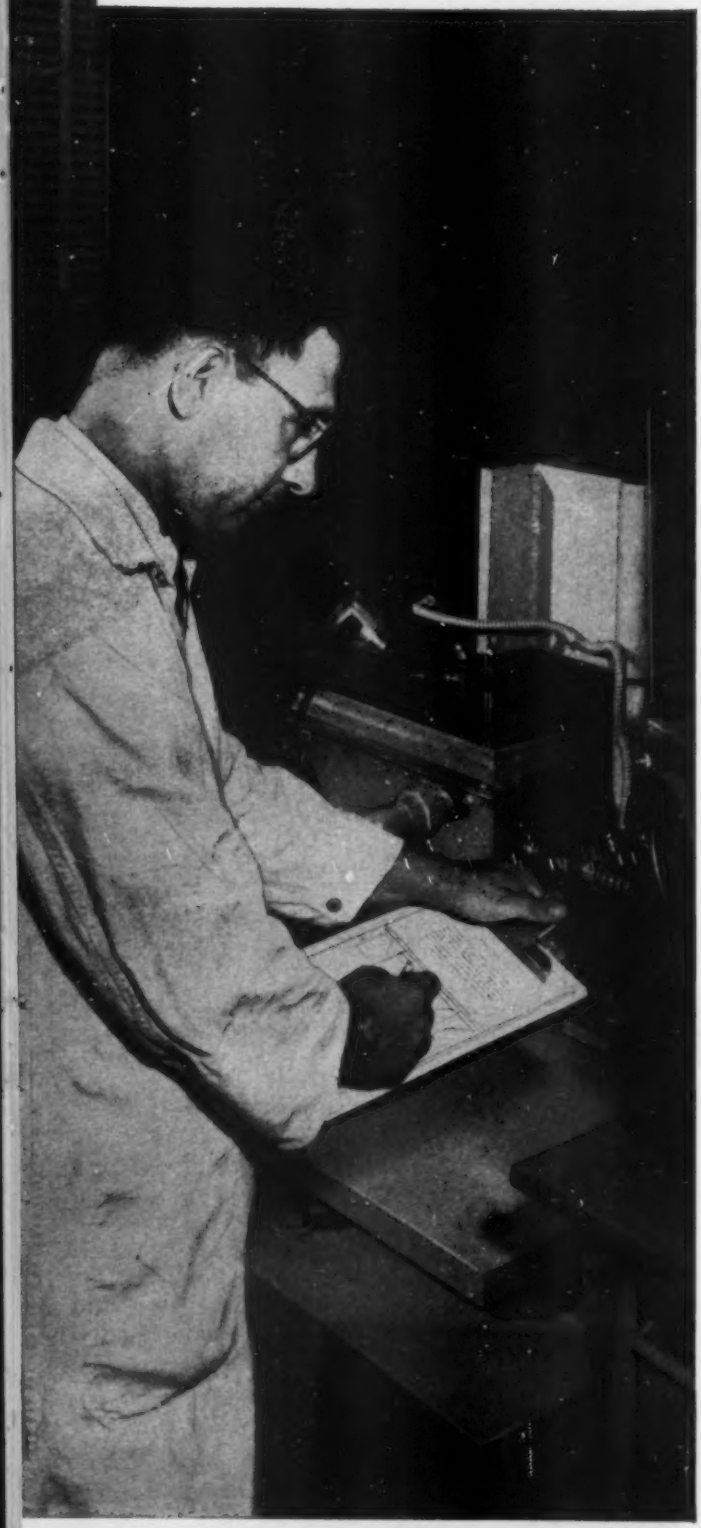
Other examples of the product design and improvement possible with Du Pont "Alathon" are squeeze bottles, battery parts, pipe, flexible housewares, toys, TV lead-in wire and cable insulation ("Alathon" also has excellent dielectric properties). Perhaps this combination of properties can help you. For full information, write: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 109A Du Pont Bldg., Wilmington 98, Delaware.

*REG. U. S. PAT. OFF.

Containers molded by
A. L. Hyde Co., Grenloch, N. J.,
for Tennessee Products & Chemical Corp.,
Nashville, Tenn.

DU PONT
REG. U. S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY
Polychemicals
DEPARTMENT
PLASTICS • CHEMICALS

Here's a short cut to selecting wet clutch facings



When you're looking for a facing material for a new wet clutch design, it would save time and experimental expense if you could safely confine field tests to only a few likely materials. A practical means of taking such a short cut is one of the results of the basic research on clutch facing materials now being done in Armstrong's Research and Development Center.

The key to this laboratory work is the Armstrong-built test equipment shown at left. This unit is helping to get answers to a lot of basic questions. For example, what is the effect of varied operating temperatures on a given organic friction material? Or the effects of changing speed, pressure, oil, or variations in compound formulations?

The answers to such questions are being developed under standard, controlled conditions. This information allows Armstrong to guide you more directly toward the one material that will do the best job in your particular clutch design.

Unfortunately, there's still no way to predict the effect of varying mechanical designs on facing performance. This means, of course, that your initial tests must be run on materials chosen on an educated guess basis.

Often, however, you'll find that one of these first Armstrong materials will meet your torque and engagement requirements. If not, then a comparison of your field test results with our laboratory data on the same compounds will indicate which other Armstrong's material you should test or point to the modifications needed to fit a standard compound to your needs. This controlled method of facing selection obviously can save you both time and expense.

If you're working on a wet clutch now or would like to improve the performance of an existing unit, write for a copy of our "Clutch Facing Data Sheet." We'll be glad to study the data you submit, suggest suitable materials, and supply samples for your experimental use. Armstrong Cork Company, Industrial Div., 7309 Irvin Street, Lancaster, Penna.

ARMSTRONG'S FRICTION MATERIALS

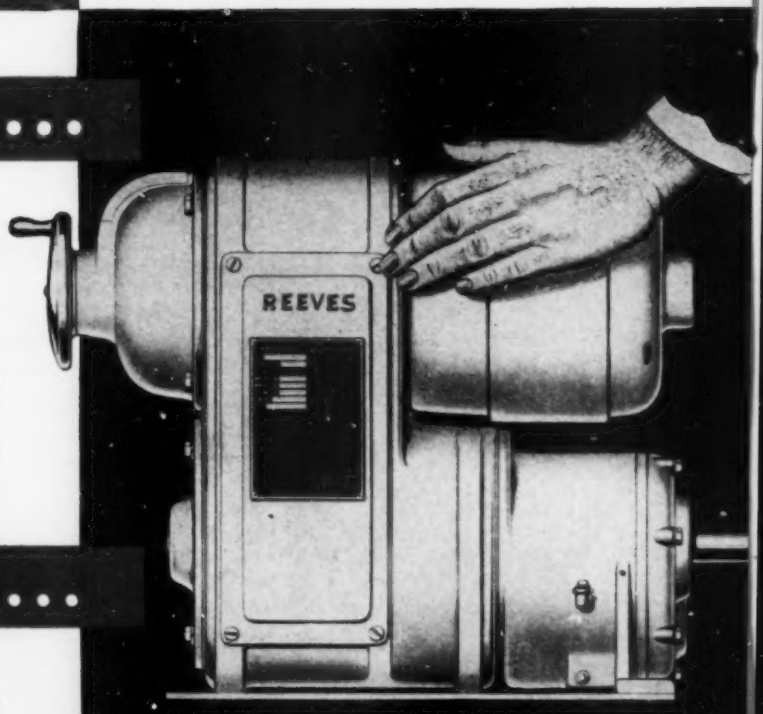
REEVES Variable Speed Drives

Any you

with Motodrives . . .

● Small, compact, but ***rugged*** REEVES Fractional hp Motodrive gives increased output, greater efficiency and uniform production from your light machinery. In one space-saving unit encased in newly-designed, lightweight housing, REEVES Fractional hp Motodrive brings you: A standard NEMA face-mounted motor and REEVES time-tested speed varying mechanism for positive, accurate, speed changes without stops. Horizontal units are $9\frac{5}{8}$" high; vertical units $16\frac{7}{8}$" high. Available in $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$ and $\frac{3}{4}$ hp capacity with speed ratios up to 10:1.

For heavier duty, ***integral*** hp REEVES Vari-Speed Motodrives are available with capacities to 30 hp and with speed ratios from 2:1 through 6:1.



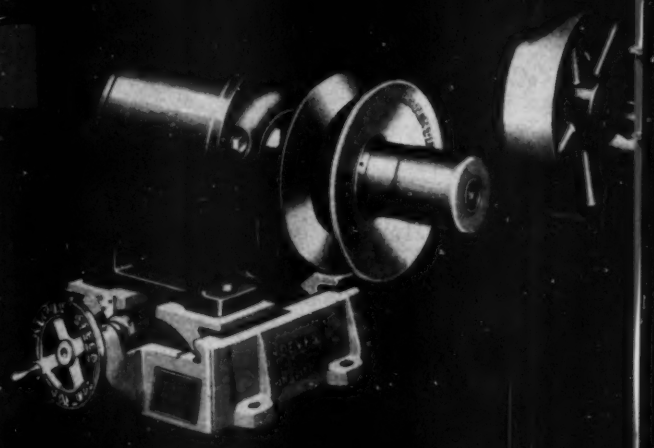
with Flexi-Speed Drive . . .

● For extreme versatility in operation and application, *simplicity* and *economy* in installation and ***speed range of 8:1***, choose REEVES ***new*** Flexi-Speed Drive. Essentially a Motodrive without housing, REEVES Flexi-Speed Drive is a compact combination of constant speed disc assembly with shifting mechanism, mounted on the drive shaft; variable speed pulley mounted on the driven shaft; and double-cog belt linking the two. Converts any standard motor into a highly flexible variable speed drive. Easily adapts for right angle applications. Available in $\frac{1}{2}$, $\frac{3}{4}$ and 1 hp capacities.

with Motor Pulleys . . .

● Boost your production in light or heavy duty work applications by converting your fixed speed motors to infinitely variable drives with REEVES Vari-Speed Motor Pulleys . . . the simplest, most economical way known to industry.

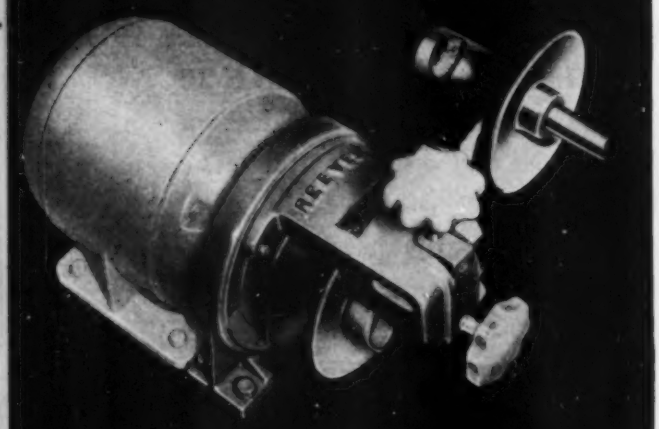
Two styles available—Vari-Speed Junior, for use with Standard A or B section V-belts, carrying loads up to $1\frac{1}{2}$ hp; Standard Line, using REEVES Vari-Speed belt, sizes up to 10 hp. Speed ratios as high as 4:1 inclusive.



REEVES VARI-SPEED MOTOR PULLEY

speed need

-anywhere you need it! fractional to 87 hp



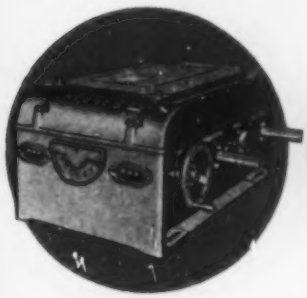
REEVES FLEXI-SPEED DRIVE

REEVES VARI-SPEED JR.

Other Units in the Complete REEVES Line!

VERTICAL MOTODRIVE

HORIZONTAL MOTODRIVE



VERTICAL TRANSMISSION

HORIZONTAL TRANSMISSION

REEVES offers many different methods of control for changing speeds—either manually or automatically—handwheel, which is standard, electric, or completely automatic.

For machines you buy or build, obtain *all* the benefits of stepless speed adjustability by specifying **REEVES** Drives. Send for catalog, No. K87-1-3N.

REEVES
SPEED CONTROL

REEVES PULLEY COMPANY • COLUMBUS, INDIANA
Recognized leader in the specialized field of variable speed control

HEIM rod ends

reduce cost of material and assembly time . . .

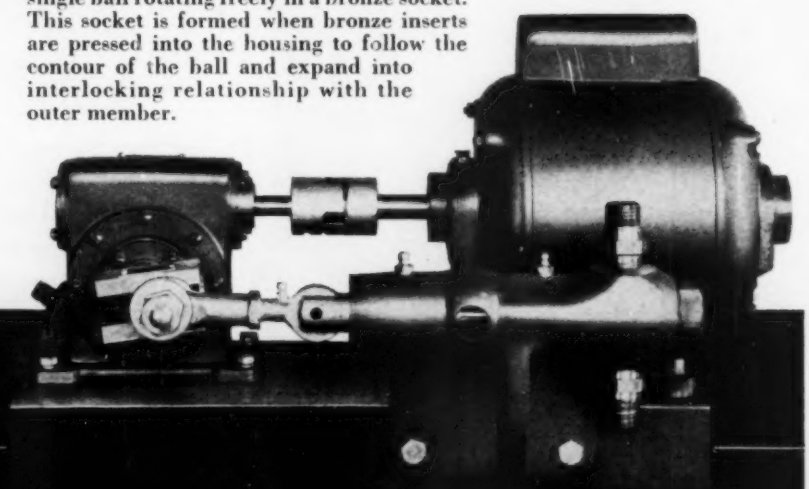
The Milton Roy Company, Philadelphia, uses Heim Rod Ends on their Model H-20 Pumps because of overall cost reduction both in material and assembly time. The self-aligning feature of Heim Rod End Bearings eliminates the need for time-consuming *perfect* alignment between the crank arm and the plunger moving in the pump frame.

This cutaway view shows the groove left between the inserts for lubrication of the single ball.

In this application, one male and one female Heim Rod End are assembled together to form the complete linkage.

The Heim Unibal principle is based on a single ball rotating freely in a bronze socket. This socket is formed when bronze inserts are pressed into the housing to follow the contour of the ball and expand into interlocking relationship with the outer member.

Please write for complete catalog of Heim Bearings.



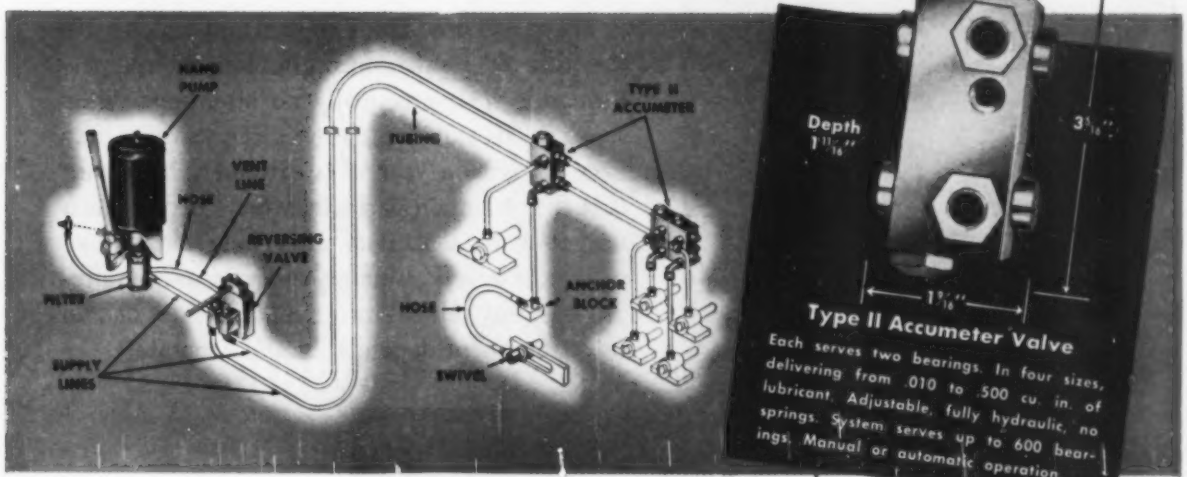
THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

developed...for "tough-job" lubrication on the largest, heaviest machines...

ALEMITE Accumeter® CENTRALIZED LUBRICATION

sealed against grit...fumes...abrasives
operates outdoors in any weather!



Alemite Accumeter Lubrication System delivers the exact, measured amount of lubricant to *all* bearings of a machine. In a fraction of the time required for hand lubrication–Accumeter measures and delivers lubricant–*while the machine is in operation!* No down time–no points missed. No wonder 95% of big plants buying machine tools want centralized lubrication!

Type II Accumeter is unmatched for simplicity of design. It's fully sealed and enclosed–yet may be serviced without being removed from machine. Operates in salt spray, severe acid or fume conditions–even totally immersed–because it may be painted or treated with non-corrosives.

Type II Accumeter System can serve single machines or groups–will handle any required lubricant–heavy or light. It is just one of three types of Accumeter Systems made by Alemite. One of them will serve your requirements.

offers...

ALL THESE ADVANTAGES!

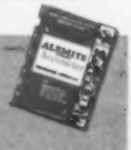
- **Eliminates shutdown time for lubrication. Adds productive time to machine output.**
- **Seals completely against dirt, grit, water all the way from "Barrel-to-Bearing."**
- **Prevents bearing troubles due to neglect or use of wrong lubricant.**
- **Services *all* bearings–including those inaccessible or dangerous–in one operation.**
- **Avoids work spoilage and bearing repairs due to over-lubrication.**

FACTORY-TESTED . . . FIELD-PROVED

Proved in the field. Exhaustive tests showed *no variation* in the amount of lubricant discharged . . . even after 73,312 lubrication cycles, *equal to 122 years of twice-a-day service.*

ALEMITE®
®REG. U. S. PAT. OFF.

A PRODUCT OF SW STEWART-WARNER



Free–Alemite Accumeter Catalogue and Engineering Data Book.

ALEMITE, DEPT. T-93
1850 Diversey Parkway, Chicago 14, Ill.

Please send me my free copy of the Alemite Accumeter Catalogue and Engineering Data Book.

Name_____

Company_____

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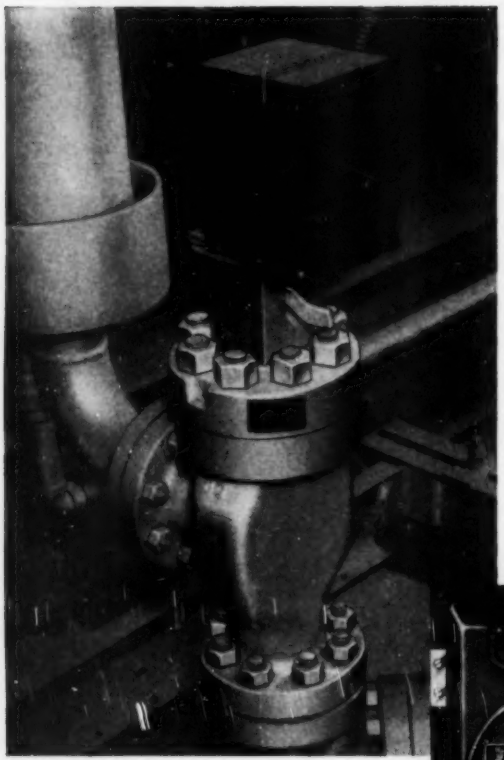
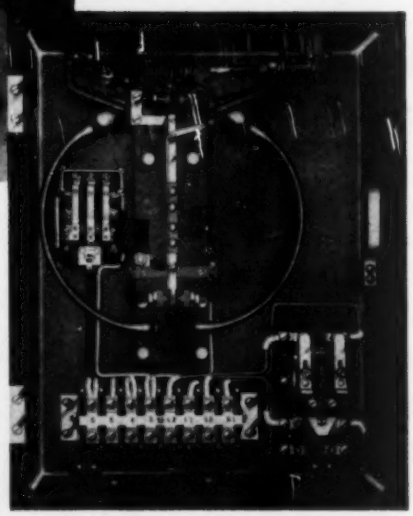
ELECTROMATIC relief valve depends on WARD LEONARD RELAYS



CONSOLIDATED ELECTROMATIC RELIEF VALVE ACTUATED BY WARD LEONARD RELAYS, keeps boiler pressures balanced within one percent of a predetermined level. This conserves power, maintains uniform line pressure and decreases maintenance of spring-loaded safety valves.

This relief valve, made by Manning, Maxwell & Moore, Stratford, Conn., is designed to increase the efficiency of steam generating systems by automatically keeping boiler pressures balanced within one percent of a predetermined value.

The relays used in the control unit which actuates this relief valve must give trouble-free performance with practically no attention. While they may be called into action frequently or only once or twice a year, it is extremely important that they function perfectly when needed. Such trigger-sharp sensitivity after long inoperative periods is a very exacting and unusual requirement for any relay. Ward Leonard relays handle this assignment dependably and accurately.



PERFECT PERFORMANCE, even after months of inoperation, is required of the electrical control unit. To meet this very severe and unusual operating condition, Ward Leonard 110 and 130 relays shown here give trouble-free performance with little or no maintenance. The midget 110 relay will open or close circuits up to ten amperes. The two-pole 130 relay can be economically adapted to a variety of applications by varying interchangeable parts in its assembly.

WARD LEONARD

WARD LEONARD ELECTRIC COMPANY

MOUNT VERNON, NEW YORK

Result-Engineered Controls Since 1892

WARD LEONARD'S attention to every detail in the construction of relay components gives you accurate, dependable performance

CONTACT PRESSURE OF EVERY RELAY is measured on a gram gauge in Ward Leonard's Mount Vernon plant.

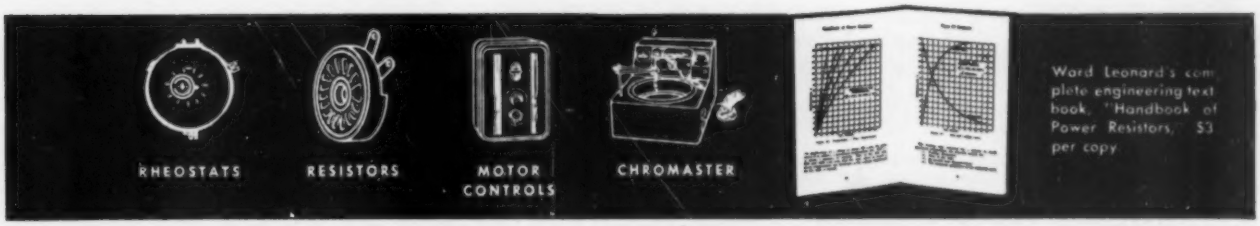
Take the Ward Leonard relay coils, for example. All magnetic relays have coils, but there can be a world of difference between them. Here's how Ward Leonard insures perfect performance in every relay coil as a routine production procedure:

Coils are layer wound using insulated magnet wire with insulating paper between each layer. They are vacuum impregnated with heat reactive varnish. Their ends are sealed with an end seal compound. Insulated tape used for anchoring provides auxiliary insulation. The outside wrap provides excellent mechanical protection. The final finish dip in insulating varnish provides a virtual hermetic seal for the coil.

These features of the relay coil are indicative of the detailed attention given to every component of Ward Leonard relays. And after the components are assembled, all finished relays are measured for resistance, close dimensional tolerances, pick-up, drop-out, dielectric strength and contact continuity.

Whether you make heavy industrial equipment like the Electromatic Relief Valve, or highly sensitive electronic apparatus, there's a Ward Leonard electrical control that will meet your needs.

For complete information, write for our Relay Catalog. Ward Leonard Electric Co., 63 South St., Mount Vernon, New York. 3.15



When Nobody Knows the Answer

One of these days you may come face-to-face with a metal problem that does not seem to have an answer.

That is the time to think of these International Nickel Company metallurgists. They are constantly improving and modifying nickel alloys to meet new conditions. They are always ready to help you with specific problems involving metals for destructive service conditions.

Over the past 50 years, Inco has developed a family of metals for hundreds of different applications. In one branch of the family, for example, is a group of heat-resisting alloys—Inconel®, Inconel "X"®, the Nimonic® Alloys and Incoloy®—all now important in high temperature work.

Elsewhere on the family tree, you will find other alloys — each with certain special characteristics. Often, there is a better-than-even chance that one of Inco's alloys offers exactly the properties you are looking for.

Of course, this does not mean that somebody at Inco can dip into the files and come up with a pat answer to every new problem. All the answers have not been found yet. But a tremendous amount of research has been done, and you can probably benefit in one way or another from it.

When nobody knows the answer, Inco's metallurgists keep going until they have investigated all possible metals and alloys that might do the job. In fact, the men in Inco's Technical Service (and in their Corrosion Engineering and High Temperature Engineering Services, as well) have one primary goal: to help you determine whether an Inco Nickel Alloy or some *other* metal will serve your purpose best.

No matter what your metal-selection problem may be, all the technical facilities of Inco are available to help you solve it. There is no charge, no obligation of any kind. For prompt technical help whenever you need information about metals, all you have to do is get in touch with: "Technical Service,"

THE INTERNATIONAL NICKEL CO., INC.
67 Wall Street, New York 5, N. Y.

NICKEL ALLOYS INCO TRADE MARK

MONEL® • "R"® MONEL • "K"® MONEL • "KR"® MONEL
"S"® MONEL • INCONEL® • INCONEL "X"® • INCONEL "W"® • INCOLOY®
NIMONIC® ALLOYS • NICKEL • LOW CARBON NICKEL • DURANICKEL®

This new idea generator packed with facts about

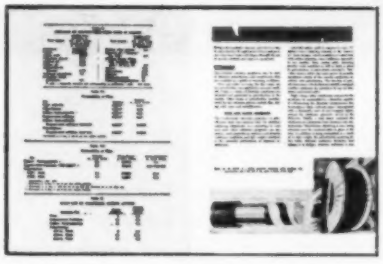
BAKELITE TRADE-MARK Polyethylene

can help turn your ideas into tomorrow's profits

New 24-page booklet shows how the unusual combination of properties of BAKELITE *Polyethylene* can make products look better, work better, cost less, and sell more.

You can see how products benefit by BAKELITE *Polyethylene's* flexibility, light weight, chemical resistance, low water permeability, excellent dielectric properties, impact resistance, formability.

You can learn the many different ways you can fabricate BAKELITE *Polyethylene* . . . how it can be injection or blow-molded; extruded as film, tubing, rod, tape, monofilaments; calendered, cast, or applied to other materials as hot-melts or by flame-spraying.



You can visualize how the advantages of BAKELITE *Polyethylene* can be applied to almost every conceivable type of product, in practically every industry . . . in revolutionizing sales and packaging, in reducing shipping costs, in solving materials-handling and installation problems.

You can plan for a bigger future, now, by investigating what BAKELITE *Polyethylene* can do for your own products, when it becomes more freely available. New plants are under construction to expand production in order to alleviate present short supply. Time your own development work so you will be ready. Start today, by writing for a free copy of this idea-stimulating booklet. Write Dept. QR-10.

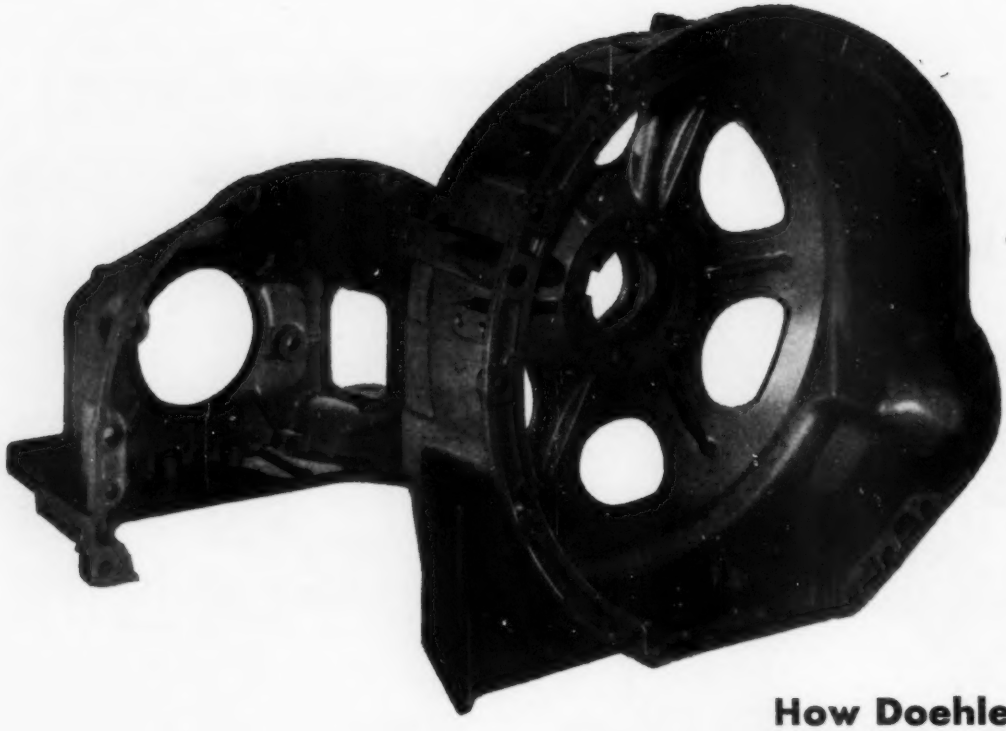
BAKELITE TRADE-MARK
Polyethylene

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

SHEAFFER SNORKEL pen has cap, barrel, plunger knob, and gripping section molded of BAKELITE C-11 Plastic, providing fine finish, good color, precise fitting, durability. Made by W. A. Sheaffer Pen Company, Fort Madison, Ia.

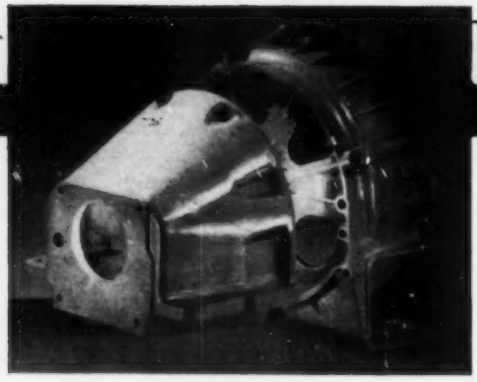
LASTING COLOR for slide fasteners is achieved with lacquer coatings based on VINYLITE Brand Resins. They withstand usage, cleaning solutions, and boiling soapy water. By Stoner-Mudge, Inc., Pittsburgh 33, Pa. for Crown Fastener Corp.

CONTROL CASE for automatic refrigerator defroster is molded of BAKELITE Phenolic Plastic, permitting simplified fast production. Molded for Paragon Electric Company of Two Rivers, Wisconsin, by Lapcor Plastics, Inc., Manitowoc, Wisconsin.



How Doehler-Jarvis

halve the weight and

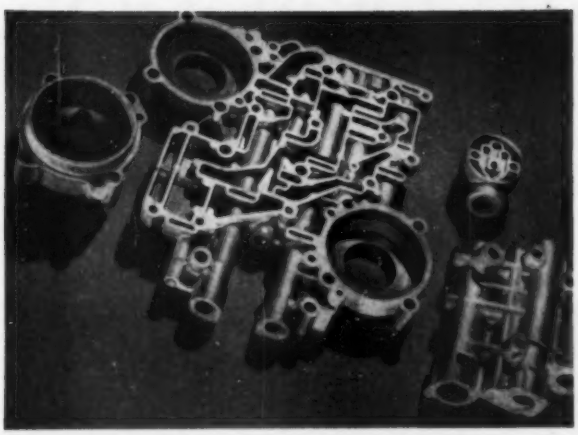


These torque converter and clutch housings are light, sound and strong. They withstand great vibrational stresses and the jarring and jouncing encountered in endless miles of "shift-free" motoring. As cast by Doehler-Jarvis, these housings provide many economies in machining costs. For one example, the long oil holes in the torque converter housing are cast-in.

Your motor car dollar buys a whale of a lot more performance than it did a few short years ago. Why? Because it pays for less dead weight and more useful horsepower. It pays for fewer heavy, slow-production parts and buys more lightweight, high-speed, precision-made units. It pays for fewer laborious fabrication steps and buys more streamlined assemblies of formed-to-fit parts.

As a case in point, consider the automatic transmission. It has become progressively more efficient, lighter in weight, part for part – and less expensive to own and operate.

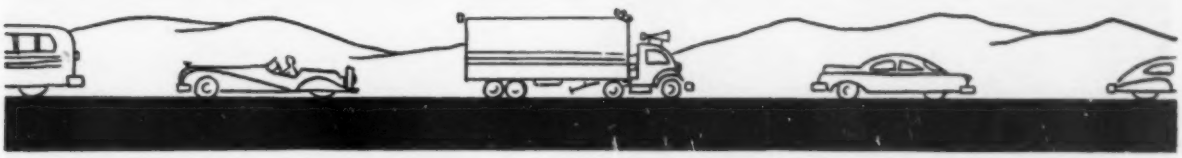
These improvements have been made possible to a great extent by the use of die cast parts, many of which are produced by Doehler-Jarvis in close cooperation with motor car makers.



Valve castings used in an automatic transmission. These parts are among the most intricate of the multitude of die castings made by Doehler-Jarvis. Obviously extreme dimensional accuracy is required for proper fit and functioning of all valve components.

Helped Motor Car Makers

lower the cost of heavy duty housings



A prime example of this teamwork between the customer's design and engineering staffs and those of Doehler-Jarvis is the set of housings – torque converter and clutch – illustrated.

These are truly heavy duty parts. Before Doehler-Jarvis entered the picture they weighed together about 50 pounds and required considerable working-over and machining prior to assembly. The Doehler-Jarvis aluminum housings weigh about 23 pounds and require a minimum of handling before assembly.

This is but one example of how the Doehler-Jarvis organization, with resources and resourcefulness developed during a half century of die casting, works hand-in-hand with makers of metal products—in the automotive, household appliance, office machine, electrical merchandise and many other important industries.

Call in Doehler-Jarvis when you are faced with problems in the design and procurement of lighter weight, lower cost, more efficient metal parts.

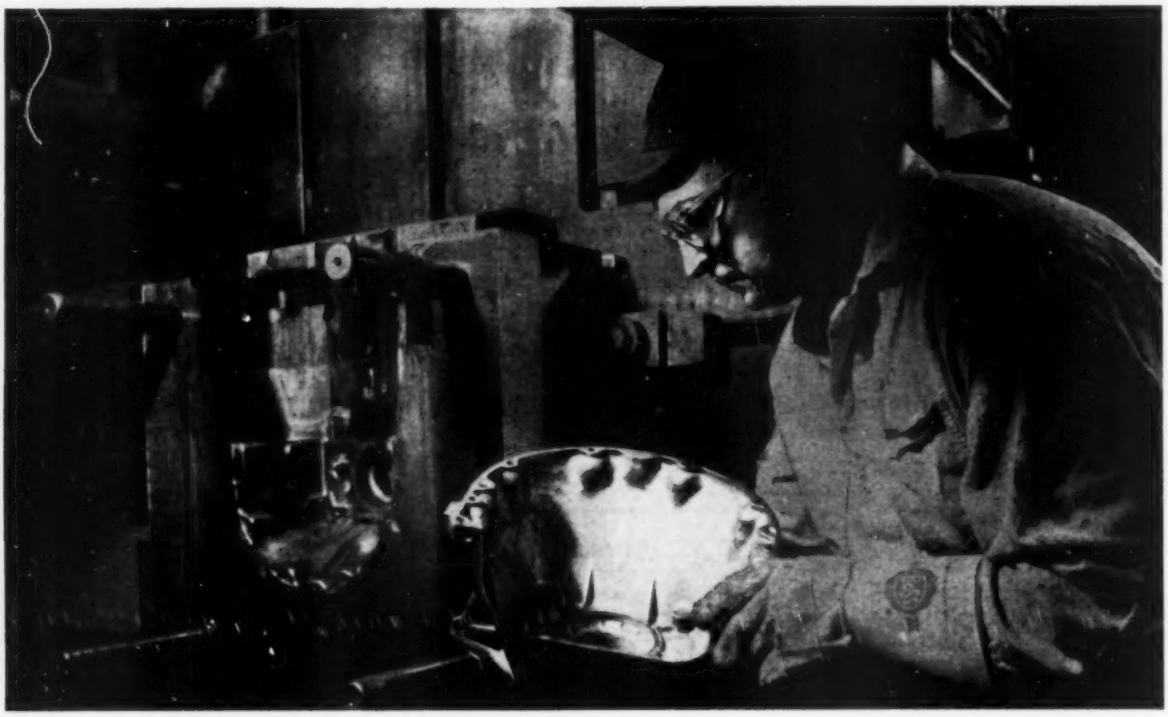
Doehler-Jarvis Division
of
National Lead Company
General Offices: Toledo 1, Ohio

*Reg. U. S. Pat. Off.

DOW

MAGNESIUM FINDS INCREASING FAVOR AS DIE CASTING METAL

Advantages of light weight, easy machinability and competitive cost make Magnesium preferable for many types of die castings



Many manufacturers are taking a new look at magnesium as a die casting metal. In today's competitive markets, magnesium offers advantages that can't be overlooked.

Take light weight. Magnesium is the world's lightest structural metal. Where weight is a competitive factor, magnesium is the metal to use. A manufacturer of portable electronic dictation equipment found that nineteen castings in zinc weighed 13 pounds, 6½ ounces; and *in magnesium, 3 pounds, 10 ounces.* That's real weight saving!

Magnesium is well known as the easiest of all metals to machine. This in itself promotes economy. As an example, the manufacturer of a lubricating machine found that the cost of machining an oil reservoir cast in grey iron was $2.05 while machining the same part cast in magnesium cost only 80¢.

Cost-wise, magnesium is better than competitive in numerous applications. One large automotive manufacturer (an industry where cost is figured on a fractional basis) has found magnesium die castings to be the lowest in cost of any metal in a score of applications. Moreover, magnesium's long-time record of price stability is also an important factor.

Now's a good time to take a close look at magnesium. For the competitive markets ahead, magnesium can offer you many advantages. Your nearest Dow office can give you up-to-the-minute information. Or write THE DOW CHEMICAL COMPANY, Magnesium Department, Midland, Michigan.

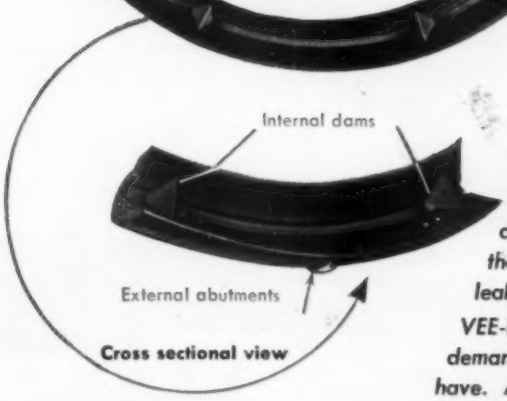
you can depend on DOW MAGNESIUM

DOW

Greatest Giant in Lockheed Aircraft's "Hall of Giants" is this 8000-ton Birdsboro deep-draw press... the largest of its type in the world. Its big main rams, in keeping with their advanced design, are sealed with LINEAR VEE-DAM Rings, the most effective modern hydraulic packing ever developed!

Foolproof to assemble
Leakproof in operation

LINEAR VEE-DAM RINGS



Cross sectional view

The unique design of LINEAR VEE-DAM Rings makes possible, for the first time, a split "V" ring packing that is really leakproof . . . ideal for hydraulic presses, pumps and pneumatic equipment.

A look at the close-up view of a VEE-DAM Ring will tell you why they seal so effectively. Those sturdy rubber dams, faced in opposite directions, are moulded into the groove hinge area of the ring, completely eliminating leakage between rings.

VEE-DAM Rings are easier to install because they don't demand the precise fitting that ordinary rings should have. And they last longer, too, because they seal perfectly tight with a minimum gland load.

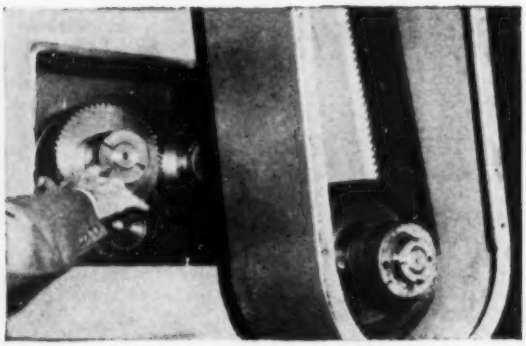
Made of a choice of fabric reinforced synthetic rubbers, LINEAR VEE-DAM Rings are individually engineered for your application. Write or call LINEAR for complete information.

"PERFECTLY ENGINEERED PACKINGS"

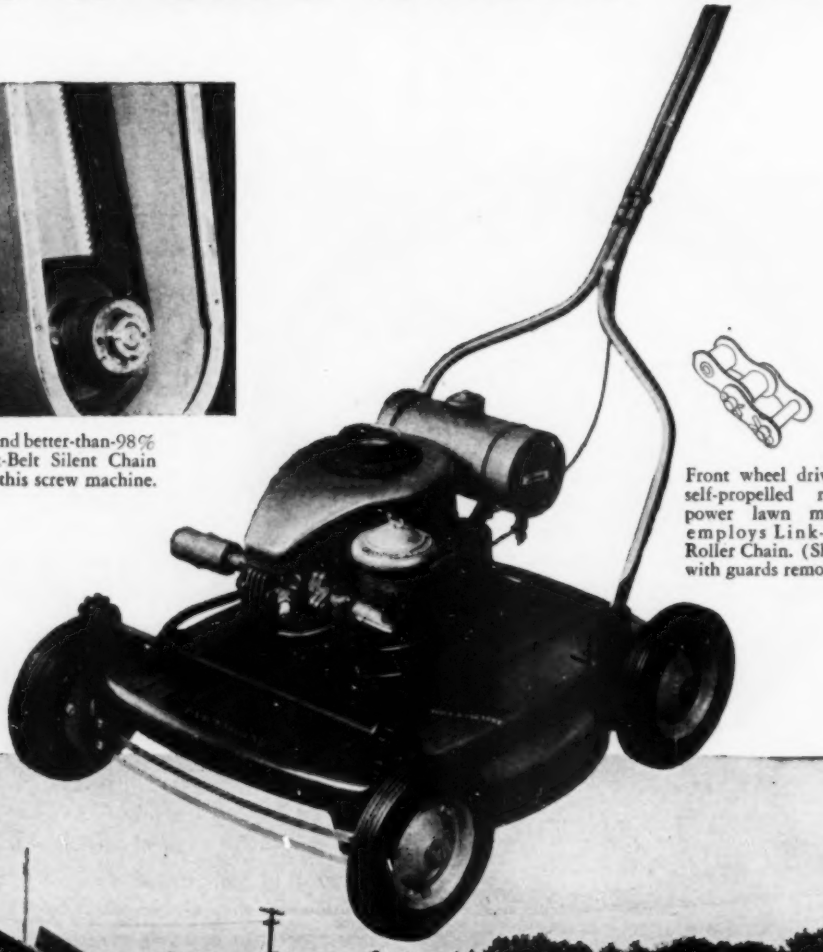
LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

Here's the sure way



The compactness and better-than-98% efficiency of Link-Belt Silent Chain are important on this screw machine.

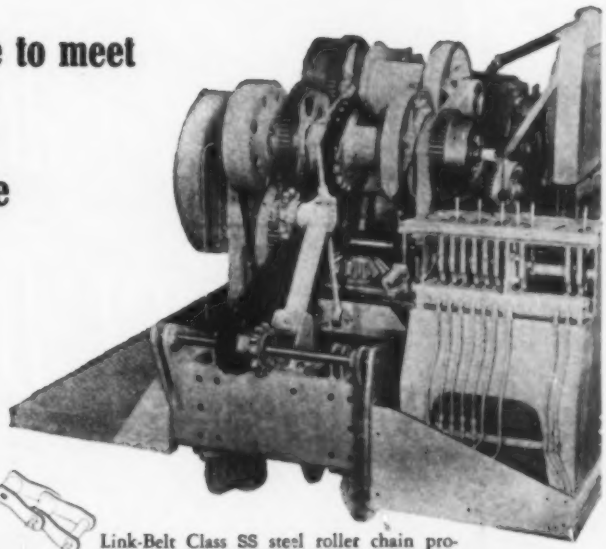


Front wheel drive of self-propelled rotary power lawn mower employs Link-Belt Roller Chain. (Shown with guards removed.)

Link-Belt steel chain and sprockets are part of the feeder-conveyor of this rugged self-propelled loader. The curved blades of the feeder, bolted to the chain attachments, serve as pick-up scoops.

to get the chain that best suits your drive or conveying job

Choose the size and type to meet your specific requirements from LINK-BELT's complete chain line



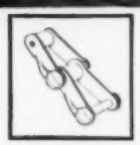
Link-Belt Class SS steel roller chain provides a positive drive yet is resilient enough to absorb impact. Here power is supplied to the boom countershaft of an outstanding shovel-crane.

LINK-BELT

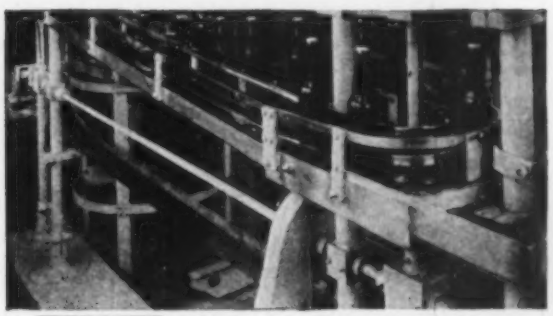
CHAINS AND SPROCKETS

LINK-BELT COMPANY: Plants: Chicago, Indianapolis, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle; Scarboro, Toronto and Elmira, Ont. (Canada); Springs (South Africa); Sydney (Australia). Sales Offices in Principal Cities. 13,322

Follow the lead of all industry—for your complete drive and conveying chain needs, rely on LINK-BELT

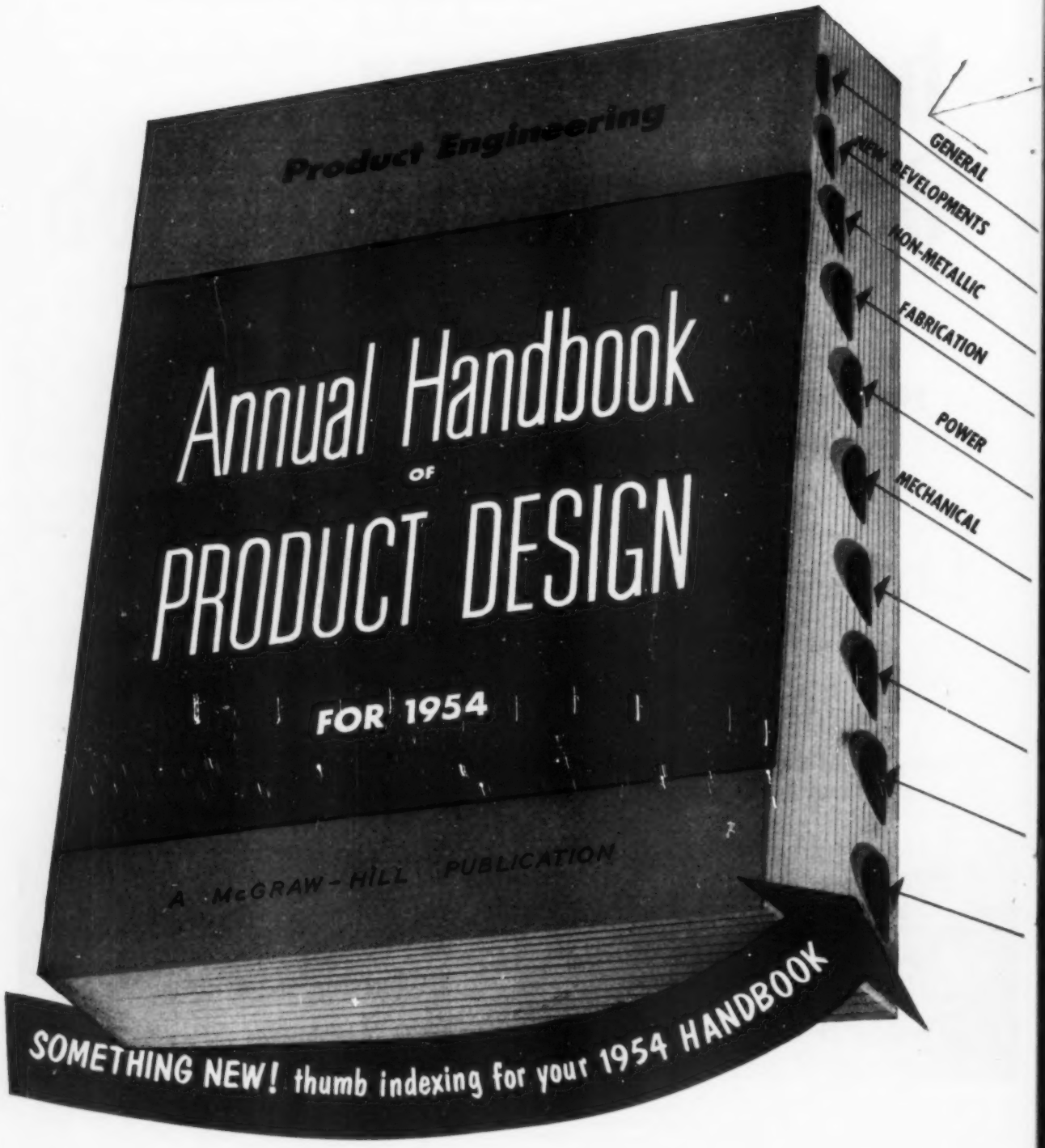


Original equipment on this mechanical lift trimmer includes 28 strands of Link-Belt Class H pintle chain: nine transfer chains at right and 19 feed chains with attachments at left.



Bottles ride smoothly on Link-Belt universal carrier chain. On this bottle elevator, flat-top chain travels around vertical curves and sharp horizontal bends.

PRICELESS DESIGN



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TRANSMISSION

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MOTORS, ENGINES, AND CONTROLS

DEVELOPMENTS IN ELECTRICAL AND ELECTRONIC COMPONENTS

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Everywhere in industry, important developments in product design come thick and fast . . . and many new parts, materials, components, and finishes are ready to do exciting and efficient jobs for you.

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But to keep abreast of *all* the important developments that are being reported upon in the world's technical press is a bigger job than you, or any other design engineer, can cope with. And *that* is why the Annual HANDBOOK of Product Design means so much to you. For here, in the pages of just *one* special issue of *Product Engineering*, are assembled for you the facts on an entire year's most significant developments in design engineering, as reported throughout the world's technical press.

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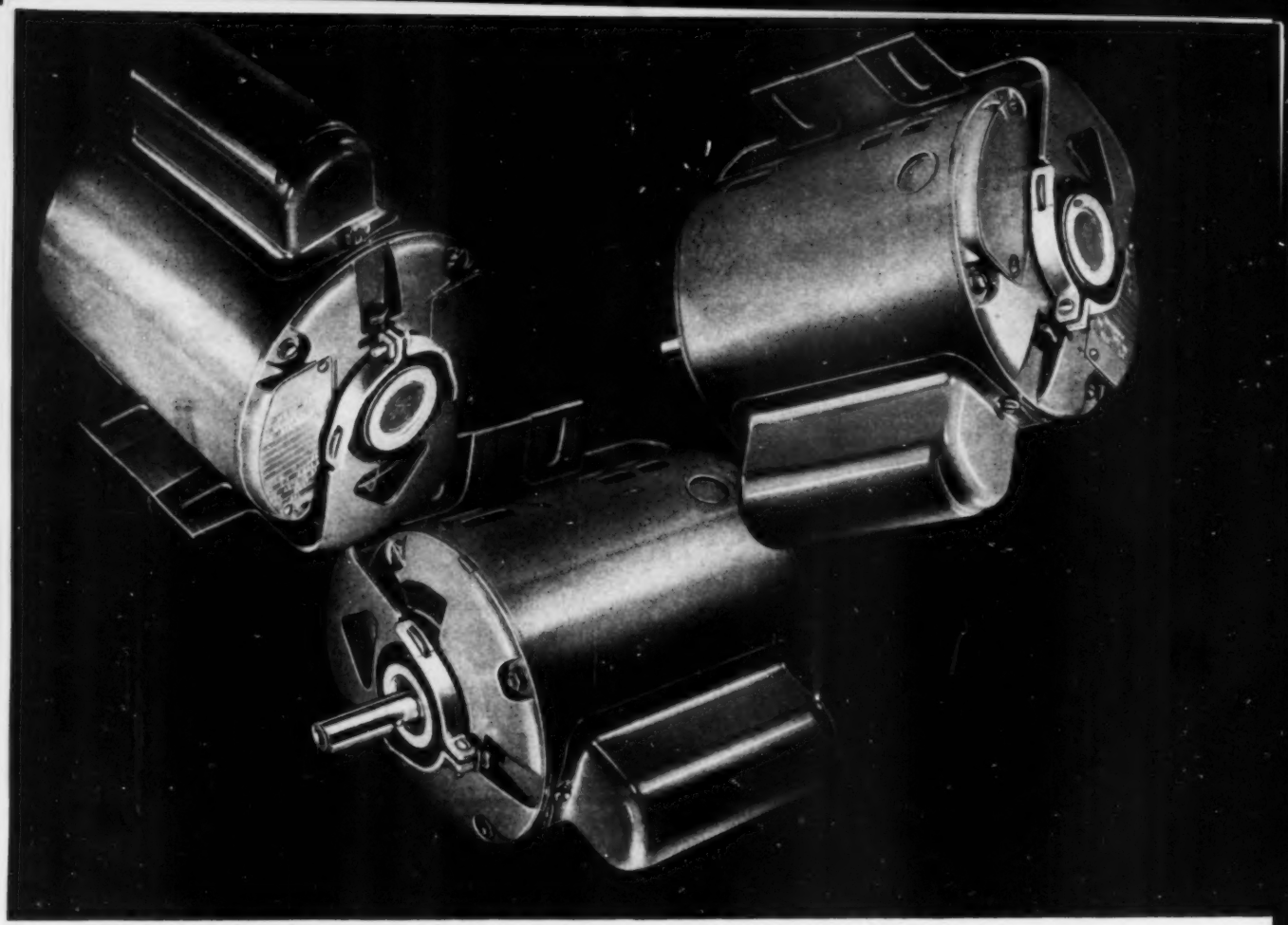
ABC ABP

KEEP YOUR 1953 HANDBOOK!

The 1954 HANDBOOK does not replace the 1953 issue. All data in the 1954 issue is entirely different from the 1953 HANDBOOK's content. To make both HANDBOOKS of maximum value to you, the 1954 issue will carry a complete index of the 1953 issue's editorial pages.



ALL-ANGLE OPERATION FEATURES of G-E's new fhp motor permit lower cost installation on applications formerly requiring a more expensive motor. Extra large oil reservoir plus features shown at right, give you an all-position motor.

Mount this standard G-E

Lubrication system insures quiet all-angle operation

This new general purpose sleeve-bearing motor gives dependable performance regardless of mounting position. A unique thrust-bearing design permits moderate-thrust loads in any direction and a new lubrication system gives full retention and recirculation of oil.

Brand new "Mylar"* polyester film . . . a *modern* insulation . . . means longer motor life. Full NEMA performance with up to 50% less weight and 40% less size means maximum power in a minimum package . . . reducing your handling and shipping charges.

For more information call nearest G-E Apparatus Sales Office or write Section 702-3 for Bulletin GEA-5567, General Electric Company, Schenectady 5, N. Y.

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*DuPont trade-mark.

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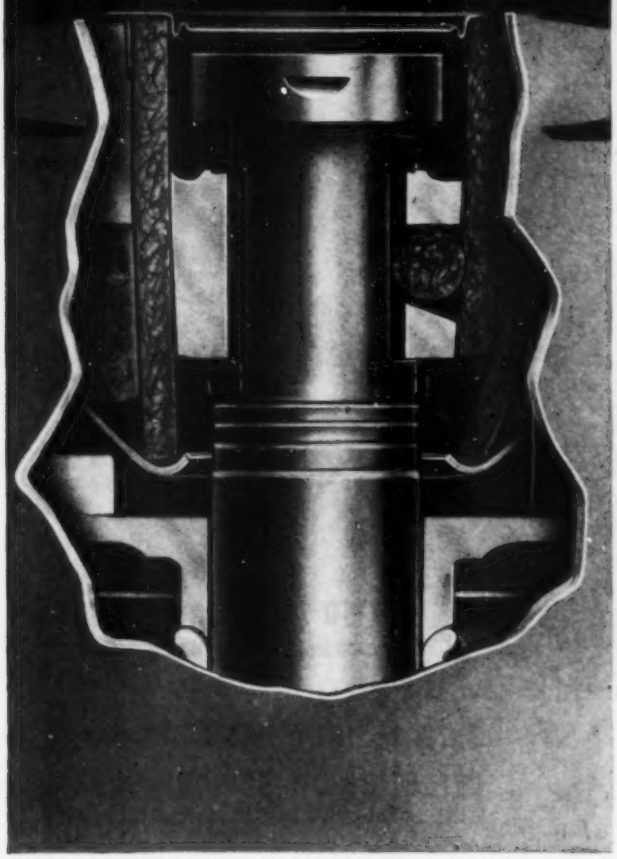
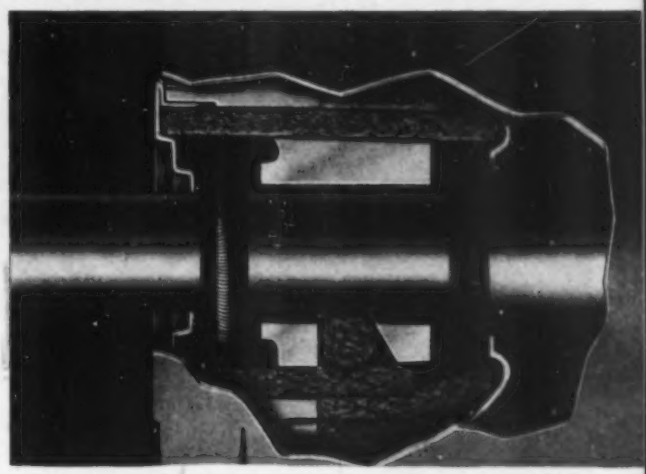
GENERAL ELECTRIC



LOCKED-IN THRUST WASHER ASSEMBLY makes it possible for this G-E motor to handle moderate-thrust loads in any direction.

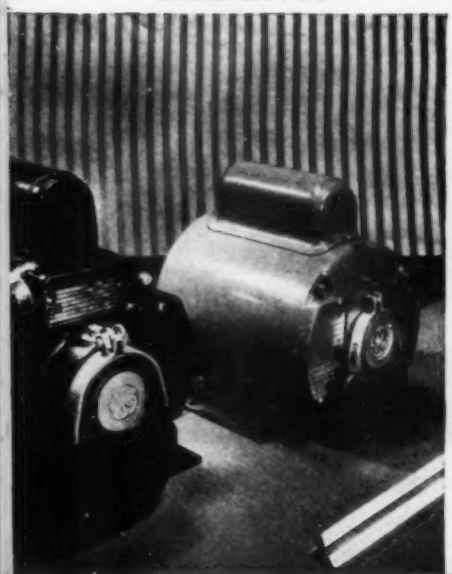
THREE LUBRICATING WICKS evenly lubricate the shaft by picking up the oil and retaining it for redistribution to the shaft.



SHAFT OIL THROWERS instantly return the oil to wicking while spring loaded thrower prevents loss of oil along the shaft.

Fhp motor in any position

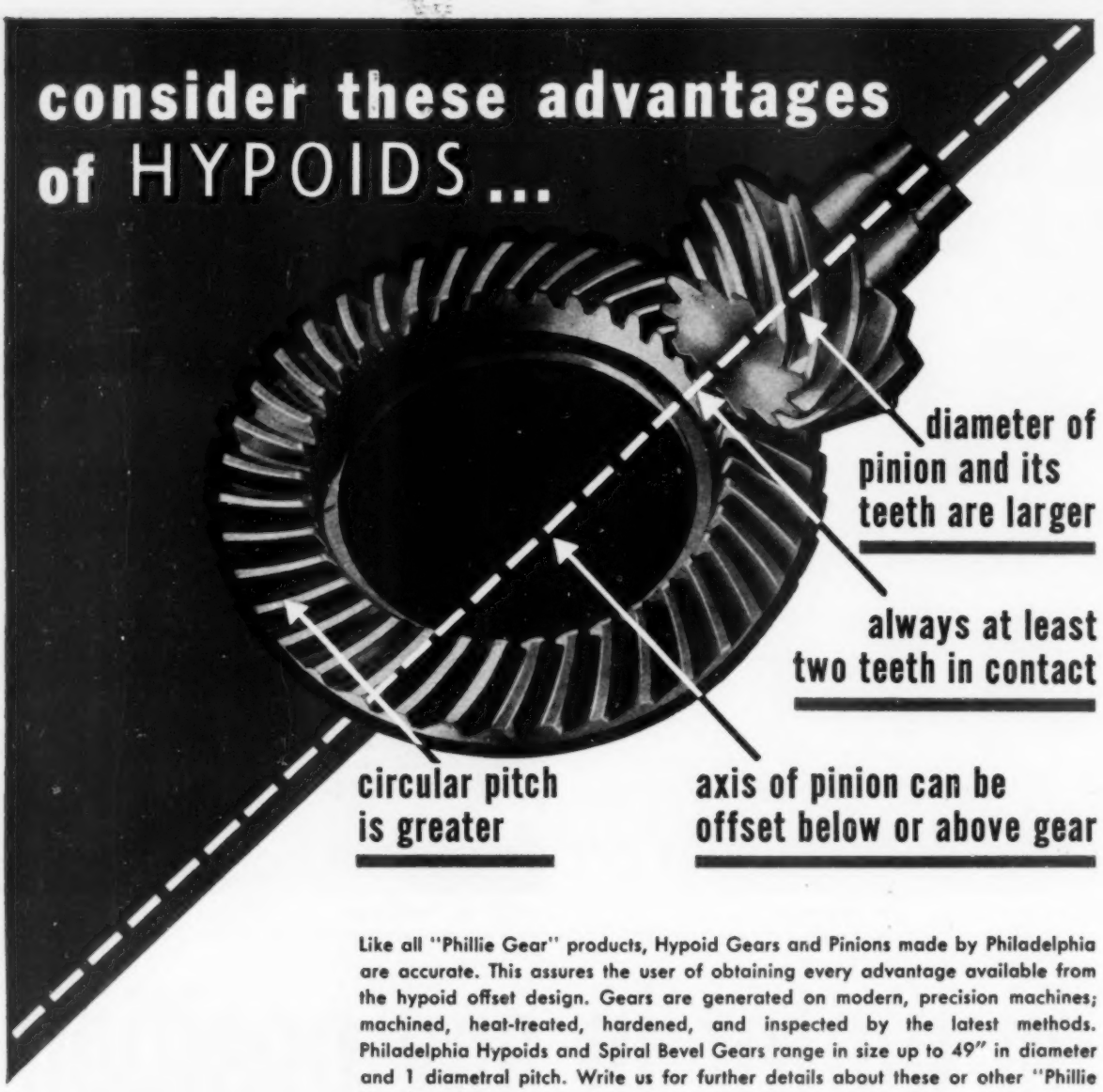
SMALLER . . .



LIGHTER . . .

BETTER LOOKING . . .

consider these advantages of HYPOIDS...


diameter of pinion and its teeth are larger
always at least two teeth in contact
circular pitch is greater
axis of pinion can be offset below or above gear

Like all "Phillie Gear" products, Hypoid Gears and Pinions made by Philadelphia are accurate. This assures the user of obtaining every advantage available from the hypoid offset design. Gears are generated on modern, precision machines; machined, heat-treated, hardened, and inspected by the latest methods. Philadelphia Hypoids and Spiral Bevel Gears range in size up to 49" in diameter and 1 diametral pitch. Write us for further details about these or other "Phillie Gear" products.

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Perspectives ~ DESIGN AND DEVELOPMENT

TOO MUCH SECURITY

One condition that needs immediate attention in Washington is the abuse of security that is causing an increasing amount of confusion. By overclassifying technical and general information, government agencies have spawned practices that are costing taxpayers millions of dollars each year. And the sheer weight of having to keep track of over-classified documents and projects is threatening to break down the security system.

Only fifteen years ago, very few bureaus had the right—or the need—to put a secrecy label on documents and activities of national interest. But today, agencies are running secrecy into the ground. They're using it for publicity purposes, to hide blunders, and even to exclude competing manufacturers from acting as government suppliers.

PUBLICITY

A frequent violation of security is aimed at bolstering public relations. An agency may classify a project so they can make a big publicity splash at a later date.

Typical example was the release of information regarding the Army's 280 mm atomic cannon. It was kept top secret until the Army held a gala press conference. Security was not a factor; the gun was shown at numerous semi-public affairs weeks before the security was relaxed.

PROCUREMENT JUGGLING

Another misuse of security is to set up government protected businesses in competition with established suppliers. Secrecy insures that a preferred source gets the contract and that no outsider can come in with a lower bid. Here's how this can be worked:

Under most procurement regulations a classified product cannot be put out on an advertised basis. It must be negotiated. If a government-employed technician develops or modifies a device for atomic energy work, the device is classified even though the gadget may not be intrinsically secret itself. But that is enough to prevent most outside suppliers from seeing it.

This practice has been responsible for the establishment—to make one part or device—of many small companies whose principals work for the government or have an "in". They become sole suppliers of the item, protected not by patents or copyrights but by the cloak of secrecy.

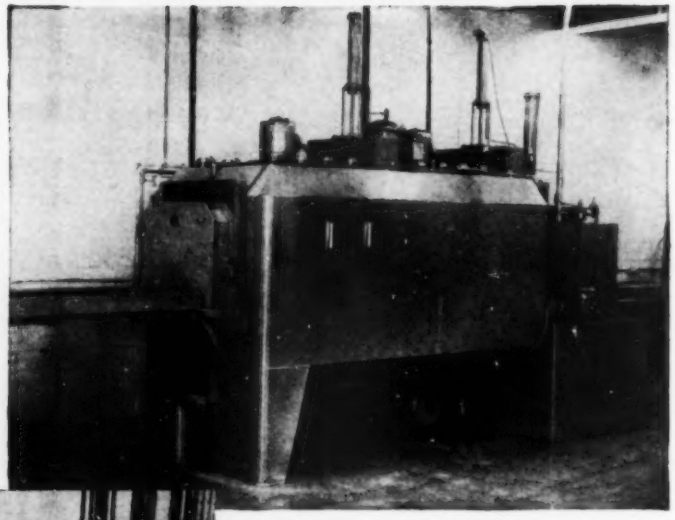
PROTECTING INEFFICIENCY

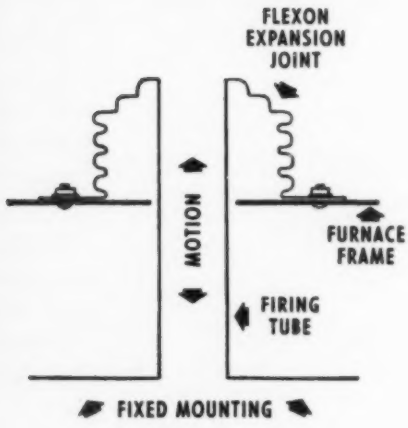
Classification can provide an agency with more protection than it deserves. By making the operation a state secret, officials are able to bury expensive mistakes, justify budget requests without revealing embarrassing details, avoid hostile criticism, and operate almost without any regulation or control.

(Continued on page 125)

Here's how

FLEXON EXPANSION JOINTS solve a difficult motion problem in this heat treating furnace





In the heat treating furnace illustrated above, which is manufactured by Ipsen Industries, Rockford, Ill., the unit is brought to temperature by burning gas in vertical tubes that extend through the furnace. Thermal expansion of these tubes at 1000° F. presented a mounting problem that was solved by attaching the free end of the tube to a FLEXON Expansion Joint, which in turn is mounted on the furnace frame as shown in the drawing. To combat the high temperatures and corrosive conditions, the expansion joints are fabricated from No. 321 stainless steel.

This is the type of problem that is a specialty of Flexonics Corporation. Whenever you have a connection problem, whether it be caused by expansion, flexation or vibration, let Flexonics know-how solve it for you.

Flexonics Catalog No. 128 gives full information on Flexon Expansion Joints and other motion control problems. See also the Flexonics catalog in Sweet's.

Flexonics *Corporation* EXPANSION JOINT DIVISION 1351 S. THIRD AVENUE · MAYWOOD, ILLINOIS

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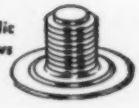
Flexon identifies products of Flexonics Corporation that have served industry for over 50 years.

Flexible metal hose

Expansion joints

Aircraft components


Metallic bellows

SECURITY RULES

Authority to classify technical data stems from a desire to protect the United States. Here's how security should be used.

RESTRICTED: Information not for general distribution because of policy reasons, not involving the security of the country.

CONFIDENTIAL: Information to be confined to those persons whose official duties require that they have such material. Release would be prejudicial to the interests of the U. S. without jeopardizing national security.

SECRET: Information of such a nature that its release would jeopardize national security.

TOP SECRET: Information of such value to a foreign nation in prosecuting its interests against the United States, that release of it would vitally injure this country or its allies.

One of the big objections to misusing these ratings is what it does to costs. Some estimates figure the government could save up to a quarter of a billion dollars annually by a more judicious use of security.

ADDING UP EXPENSES

It's easy to see how expenses add up: Every piece of paper, classified confidential or higher, must be kept in a fireproof locked cabinet which, in many cases, must also be a combination type safe. Confidential material has to be mailed in double envelopes. Material rated higher than confidential cannot be mailed—it must be delivered by messenger or armed guard. All secret documents have to be burned when they become obsolete, the burning has to be witnessed by two officers, and a record must be kept of what was burned and when.

There's a personnel problem, too. People handling these documents have to be "cleared for security", an act that requires a thorough investigation by the FBI, who are already swamped by a two year backlog of investigations.

SCIENTISTS' COMPLAINT

Scientists and engineers have a different kind of complaint: overclassification is slowing up technological progress. Too much security breeds duplication of efforts, wastes manpower and money, and sharpens the impact of the technical personnel shortage.

However the big worry of many government employees is what the huge volume of overclassified papers has done to the ordinary communications channels. It has fouled the system up so that anything classified lower than secret is likely to be ignored as trivia. The situation is undermining the whole security setup and threatens wholesale loss of our secrets unless a more intelligent attitude about classification is adopted.

CLEANING UP

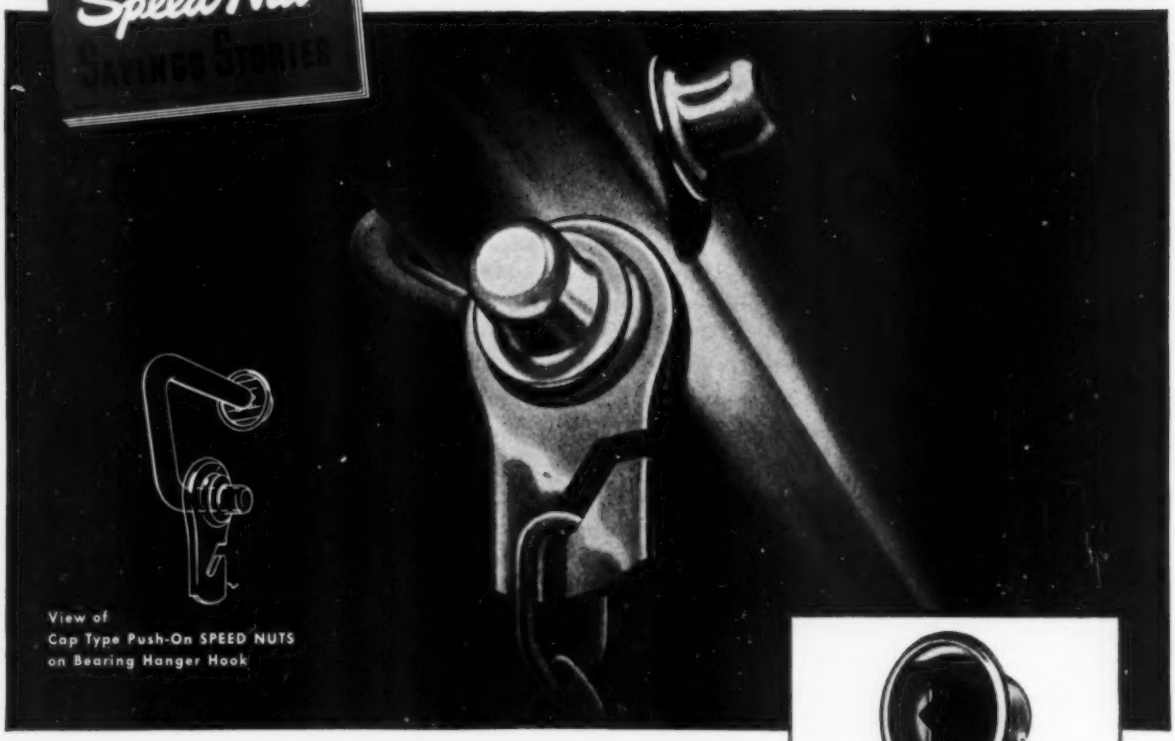
Nobody—even the severest critic—advocates abandoning the principles of information classification. The U. S. has certain vital secrets that must be protected. But there's an increasing clamor to correct some of the current malpractices. Here's one approach to cleaning up the problem:

First review what agencies have the right to classify information, taking away the privilege when a bureau cannot meet the requirements as set forth by the definitions of classified data.

Then apply stricter regulation of the use of security stamps making top ranking officials as responsible for improper classification as they are for proper security.

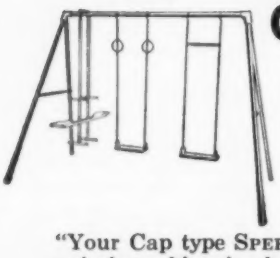
FASTEST THING IN FASTENINGS®

Speed Nut Savings Stories



View of
Cap Type Push-On SPEED NUTS
on Bearing Hanger Hook

"Swings" to Tinnerman SPEED NUT® Cuts Production Costs 60%!

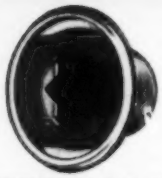


This Tinnerman SPEED NUT brand fastener helped Engineers at Eastern Pipe Supply Company, Philadelphia 22, Pennsylvania, solve a fastening problem and substantially reduce assembly costs.

In their own words, here's what happened: "Your Cap type SPEED NUT, used in conjunction with our special swivel-proof bearing hanger hooks has been a terrific sales attribute. In addition to affording our 'Safe-Play' Gym Sets a streamlined appearance it has cut our production costs by 60%.

We are extremely gratified with the performance of Tinnerman SPEED NUTS and will continue applying them to our products wherever possible."

No matter what fastening problems you may have on your products, the Tinnerman representative can help your engineers solve them. See him soon for full information on our Free, Fastening Analysis service designed to save your production dollars.



TINNERMAN CAP TYPE PUSH-ON SPEED NUT FASTENER

This is a special Push-On type SPEED NUT. Two are used for each hanger hook attachment. They zip over the unthreaded ends of the bearing hanger itself, holding hook to bearing, and hanger to swing frame. Spring steel prongs bite-lock, give rigid, vibration-proof fastenings; eliminating materials and materials handling.

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TINNERMAN Speed Nuts®

MORE THAN 8000 SHAPES AND SIZES

The Understanding Mind

ONE OF TWO MEN discussing the shortcomings of an absent individual said, "He is the laziest cuss I have ever met and he certainly ought to feel ashamed of himself. A man like that is a disgrace to himself, his family and his friends. If I had my way I'd put him on the job of making little rocks out of big ones. He ought to be in jail and forced to work."

Said the other man, "I sure do feel sorry for him and his family. It must be awful to be afflicted with such laziness. It is hard to understand why such a fine man should have such a terrible handicap. But did you ever hear him play the piano? He's a whiz at it! I bet if we could get him interested in an orchestra he would work at it day and night!"

It is common for two people to express such vastly different viewpoints on the same situation. The first man condemned harshly, saw nothing good in the situation and offered no constructive suggestions. The second man expressed sympathy and understanding, called attention to an offsetting attribute and suggested a possible way to rectify the situation.

It is the easiest thing in the world to become an expert on criticizing. There is so much to practice on. He who roundly condemns often does so to cover his sense of inferiority or a guilty conscience. On the other hand he who tries to be understanding and sympathetic looks upon glaring shortcomings as proofs of hidden attributes.

The same human attitudes prevail when the product engineer is analyzing the creations of his competitors. The harshly critical designer will see in his competitors' products only towering defects that to him rule out the possibility of their commercial success. The designer who has understanding concentrates on finding the points of superiority in his competitors' designs. He glosses over the imperfections knowing that there must be compensating qualities. These he finds and analyzes carefully and completely.

Sometimes the situation is reversed and the engineer finds himself at the receiving end of a torrent of criticisms, and perhaps even derision and abuse. He is in glorious company. Robert Fulton, Goodyear, McCormick, Pasteur, and many other leaders in progress had such experiences.

Much courage and a strong sense of humor is needed to contend with unfair criticisms or abuse. One is reminded of the remark made by Voltaire. He had just spoken about his next door neighbor in glowing terms. "I am surprised to hear you say that," said a friend, "your next door neighbor just recently cursed you and derided you." To which Voltaire replied, "Perhaps my neighbor and I are both wrong."

The world did not progress by dwelling upon mistakes but by avoiding their repetition and building upon the good accomplishments of the past. The builders were men who sympathized with human frailties and toiled unceasingly to reach their self appointed goals. Courage, understanding and a sense of humor carried them to success.

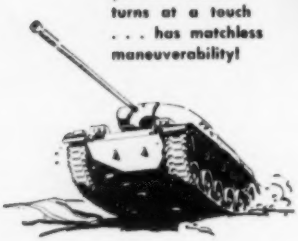
George F. Jordenholt

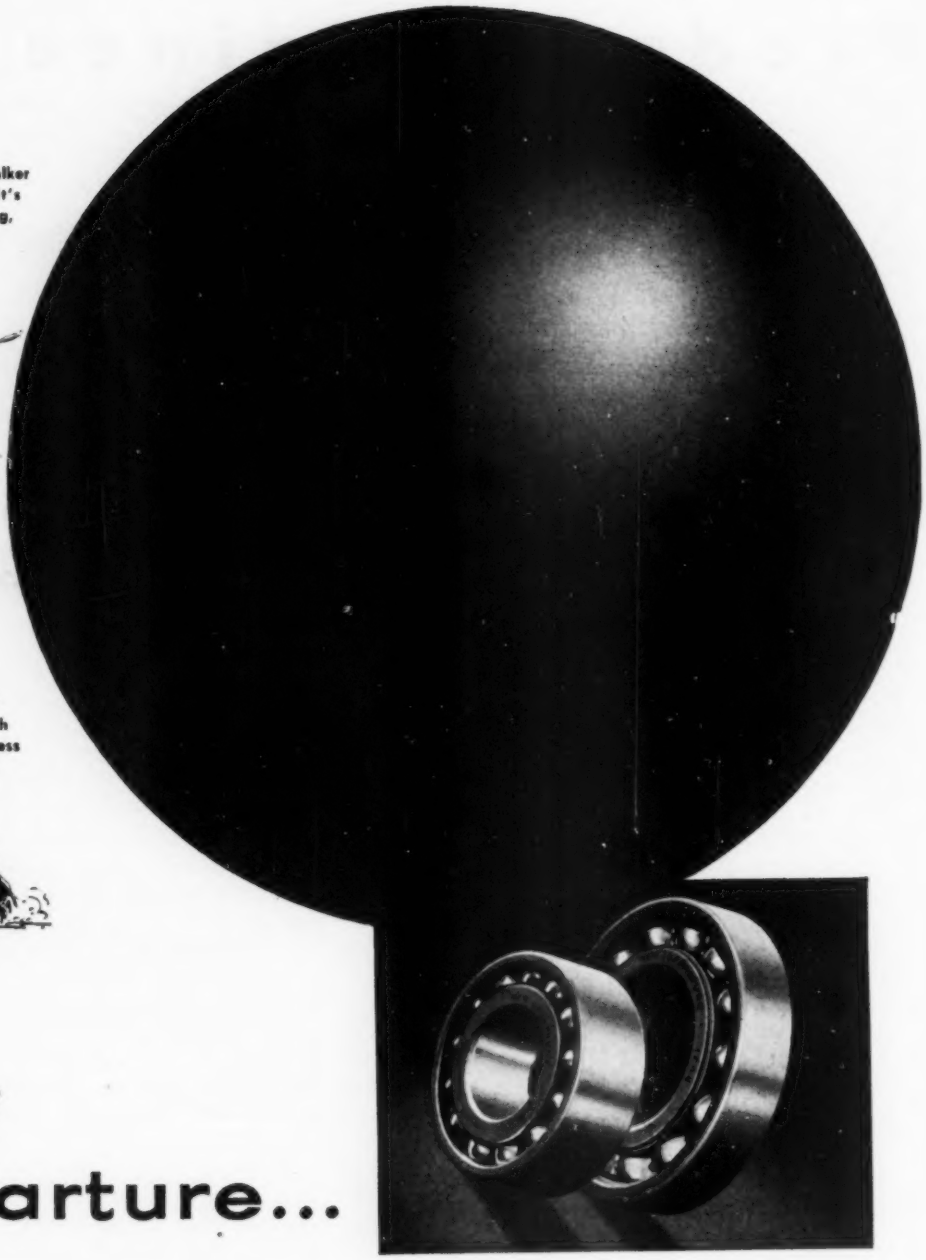
new speed

Watch that Walker Bulldog roll! It's the hardest-hitting, swiftest-striking tank of its type!

new agility

Twenty-six tons of armored fury, yet the Walker turns at a touch . . . has matchless maneuverability!





New Departure...

The Walker Bulldog is unequaled for ease of control—thanks to its CD-500 transmission, developed by Allison Division of General Motors. The CD-500 makes the driver's job much easier by hydraulically performing the functions of steering, shifting and braking.

In such an intricate mechanism, thousands of inter-connected moving parts must be supported with *sustained accuracy and rigidity*. This is the job performed by New Departures in many bearing applications in the CD-500. New Departures locate shafts in perfect alignment, and gears in exact pitch-line contact, under both radial and thrust loads. They maintain this accuracy without need for adjustments or time-wasting service.

In all transmissions, New Departures assure longest life . . . lowest frictional losses . . . maximum power output.

NOTHING ROLLS LIKE A BALL

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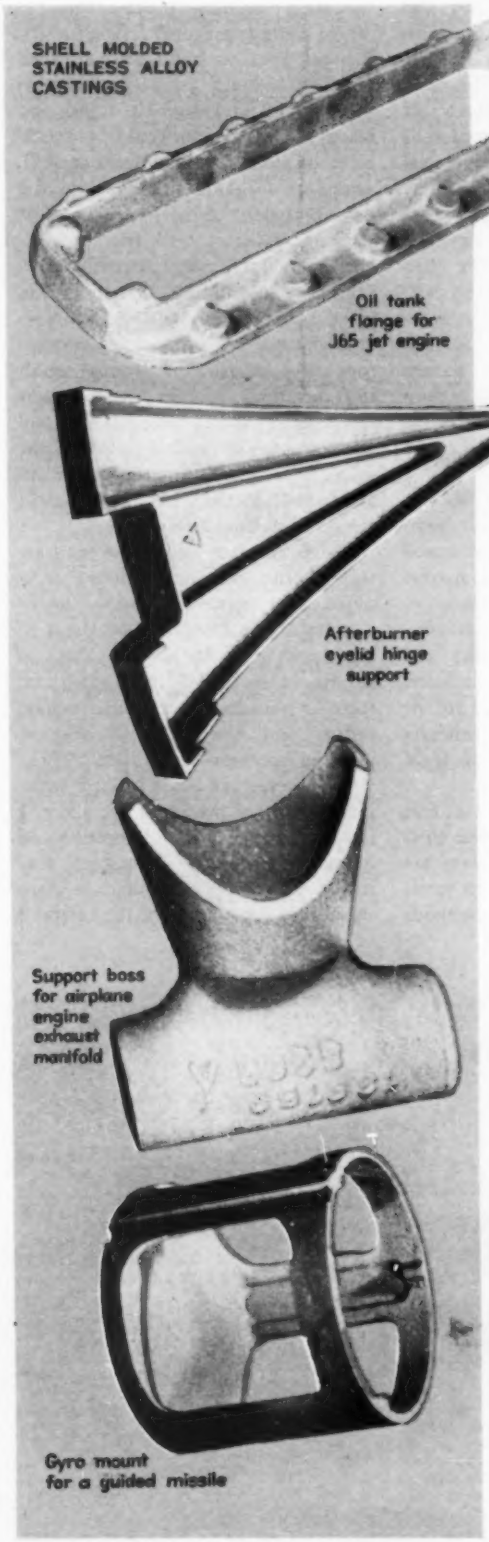


Shell Molding of Stainless Steel

In a comparatively brief period, shell molding has received a tremendous volume of publicity, mostly from the viewpoint of the foundryman. This article looks at shell molding from the standpoint of the engineer, who must, if he is to produce successful designs, have some understanding of the advantages, limitations and capabilities of this important process.

WALTER H. DUNN, Foundry Superintendent
ROBERT E. DAY, Staff Engineer
Solar Aircraft Company

SHELL CASTING of stainless steel and the so-called super alloys has three major advantages: First, there is greater latitude for designing parts, and castings can be used where they were previously considered unfeasible; second, shell castings of alloy steels often make it possible to reduce the cost of the finished part; and third, the performance of the finished part can be improved.

Increases in the length of castings are achievable because the smooth shell offers less resistance to the flowing metal. If a thin section can be run a distance of 18 in. in baked sand, the length of travel might be doubled in a shell mold. Solar has shell cast an alloy steel section 8 in. wide by $\frac{3}{16}$ in. thick to a length of 60 inches.

The surface finish obtained on shell castings is classified as being between those characteristics of sand and investment

castings. The smooth mold walls make it possible to run metal through much thinner sections at normal pouring temperature and also permit lower pouring temperatures. This results in finer grain structure throughout the casting and increased furnace life. On one part having an $\frac{1}{8}$ in. wall section, it was possible to reduce the pouring temperature from 3,050 F to less than 3,000 F and still fill the mold. Solar has also produced alloy steel parts with a 0.062-in. section, 4 in. wide and 12 in. long.

The combination of greater length and thinner sections facilitates casting of more intricate shapes by shell molding than by conventional methods. For example, it is now practical to design sections of $\frac{1}{4}$ or $\frac{1}{16}$ in. thickness in relatively large sizes for use in the as-cast condition.

Cutting Cost of Finished Part

Shell molding is approaching the dimensional control of the precision investment process, and may in time surpass it in certain areas. Since the use of shell molding, even in its present stages of development, may substantially cut down or even obviate the need for machining a casting, cost savings can be appreciable. Though the initial casting cost, using shell molding, may be higher, the finished cost of the part may be less. Thus, when considering shell mold castings as opposed to some other process, designers should be careful to obtain figures on the *finished part costs* of the alternative processes, rather than casting costs alone. Savings in finished part costs can also result from the better surface finish obtained in shell casting.

It is difficult at present to be exact about the dimensional accuracy of shell castings, but some examples of the tolerances achieved in commercial runs can be cited. Using almost any stainless alloy, parts can be produced with a $\frac{1}{4}$-in. section held to tolerances of ± 0.002 in. This is better than can be expected of a baked sand casting and approaches the best achievements of investment casting. Solar is currently producing a $2\frac{1}{2}$ in. section to tolerances of ± 0.010; and a thin-walled cylinder, Fig. 1, on which the 12-in. diameter is maintained to a ± 0.030 tolerance.

The ease with which shell castings can be reproduced makes this technique desirable for mass-produced parts. Machines now on the market are almost completely automatic in the production of shells. Under present conditions, Solar's foundry can make a shell mold in one man-minute. To bring a baked sand mold to the same finished condition, the time required would be at least five to eight man-minutes.

Another important point is that both the patterns used to make shell molds and the molds themselves are more stable and less subject to variation than those used in other methods of casting. This results in parts of high uniformity and points up the fact that there are fewer variables in the shell molding process than in other casting processes. Specifically, the principal variables are: In shell molding—pattern temperature, pouring temperature, and the sand and plastic mix; in sand casting—instability of wood patterns, operator skill, ramming techniques, removing the pattern, baking or drying cycle, the sand in which at least four ingredients can vary, mold assembly technique, core painting operation and metal pouring temperature; and in investment casting—wax mold temperature, wax temperature during molding, handling of wax pattern, wax temperature during investment, composition of wax and investment material, drying and firing cycle of investment material, metal and mold temperature at pouring time.

There are few built-in stresses resulting from the shell molding technique. The collapsibility of the molds is better, so that restraint on the casting as it solidifies is less than in alternative methods. By comparison, there is considerable restraint in sand casting and essentially no collapsibility in precision investment casting.

In general, an unrestrained stainless alloy part would shrink about $\frac{3}{8}$ in. per foot between solidification and room temperature. A casting may shrink any amount down to zero shrinkage, depending on the restraint

STEPS IN SHELL MOLDING PROCESS begin with finished part drawing from which casting and pattern are designed. The aluminum or cast iron pattern is then sprayed with a release agent (A) to ease subsequent stripping of the mold. After being heated to 500 F, the pattern is placed in a dump box or shell molding machine containing a mixture of dry sand and powdered thermosetting plastic (B). Within about 20 sec, the heat of the pattern melts the plastic, which, with the sand, forms the ¼-in. (approx.) shell around the pattern. While still on the pattern, the shell is baked for about 45 sec at 500 to 1,000 F and then stripped. Final part of the cycle is assembly of the mold and pouring of the metal. The

offered by the mold material. The difference between full shrinkage and partial shrinkage must be compensated for by plastic flow and by undesirable stresses set up in the casting.

In shell molding, the plastic bond in the shell burns away shortly after pouring, and the casting itself builds up a skin of solidified metal that holds the shape of the casting. The plastic content of the mold can be controlled to regulate the time of burning. Thus, the ready collapse of the shell at less pressure and higher metal temperature than those typical for conventional sand molds, results in less stress in the casting.

Sand inclusions are less likely to occur in shell molding than in sand casting because the mold material is much stronger and less likely to erode. In an ordinary sand mold, loose particles of sand are very apt to be included. There is, however, greater danger of sand inclusions in shell molding than in investment casting, where no sand is used and the mold is a hard ceramic. Investment casting, while not subject to sand inclusions, is subject to hard ceramic inclusions that are just as injurious to the castings. And metallic oxides as well as slag are less likely in shell molding because the process, in its adaptability to mechanization, permits better control of pouring.

Another feature is that shell castings solidify more rapidly, which promotes the formation of smaller and more uniform grains and results in improved physical properties. This is because the mold is thinner, thereby offering less insulation to cooling, and because the mold breaks away faster and allows the casting to air cool. By comparison, the resulting grains are smaller and more uniform than those of castings cooled in sand, and larger than those cooled in heated ceramic. In the case of thin-walled castings used in high pressure service, those made in shell molds are less likely to leak as a result of intergranular porosity.

Shell molding makes it possible for the foundry to take advantage of all of its technological knowledge of chemical control. Shells can be made in large quantities and stored. All castings can then be poured in one large carefully controlled heat, instead of from many small heats remelted from a so-called master melt. The chemical analysis of a master melt is often given as representing the small heat from which castings are poured. This is often incorrect. Remelting changes the chemical balance of steel and, unless proper corrections are made, the final analysis will not be the same as the beginning analysis, nor will it be the analysis desired. To run an actual chemical analysis on each small heat would be impractical from a cost standpoint.

And finally, because of the better surface finish and closer dimensional control of shell castings, less machining is necessary. The advantage is thus gained of being able to save the best part of the casting with its as-cast fine-grained surface.

Shell Molding's Place in Production

The overlap of shell molding with other major manufacturing processes is shown in Table I which compares pertinent factors. The shell technique is best suited to the irons, steels and stainless alloys. These are the metals with the highest commercial pouring

IMPORTANT FACTORS IN THE DESIGN OF SHELL-CAST STAINLESS PARTS

(1) Stresses must be considered in the range between 1,500 and 2,600 F (solidification temperature). No cracks, distortions or breaks should develop while parts cool through this temperature range.

(2) The freezing characteristics of molten metal must be kept in mind. Since castings solidify from the outside in, shrinkage may cause trouble. If there are isolated areas of heavy mass, they may become disconnected from the flow of liquid metal before they are sound, resulting in voids.

(3) Stresses caused by uneven cooling can cause a casting to fracture or distort in the higher temperature ranges. Care should be taken to equalize these stresses as much as possible.

(4) Sharp reentrant angles produce areas of stress concentration. They develop a notch effect in the casting and cracking becomes difficult to prevent.

(5) Sudden changes of mass should be avoided by generous use of tapered sections.

(6) Large flat areas of thin wall should be avoided, because they will not stay flat and oil canning will result.

(7) Small holes tend to complicate the foundry problem if they are cast in. Usually they are cheaper to drill or machine.

(8) By having one surface on the heaviest section of the casting machined, the foundryman can use this area for risers.

(9) Wherever possible the parting plane should permit the foundryman to pour in a vertical position. And from a cost standpoint, the parting plane should be restricted to a single plane.

various pieces of the mold are held in position with high-temperature cement (C) or some kind of clamp, depending on the size, shape and complexity of the part. Finished shell is then placed in production for pouring (D) or stored.

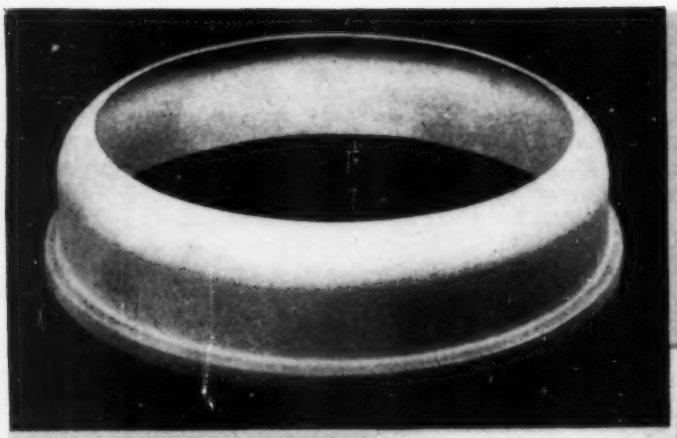


Fig. 1—(Above) Thin-walled stainless steel cylinder illustrates accuracy that can be attained on shell-molded parts. The 12-in diameter is consistently held to a tolerance of ±0.030 in. Many such castings are used in the as-cast condition, others require some machining.

Fig. 3—(Right) Experimental pattern showed that 3/32-in. top section is not practical, but 3/16-in. (next thicker) step is acceptable in shell.

Fig. 2—(Below) Port flange shows method for shell casting this section. Left to right are pattern for outer shell, core shell and cutaway of outer shell, and the finished casting.

temperatures, as well as the ones that have the smallest selection of mold materials from which to choose.

Since shell molds are strong, durable and light, they are well suited to mass production techniques and mechanization. The process is highly adaptable to various degrees of mechanization, from completely manual operation to completely automatic production. This should make shell molding competitive in short runs of premium quality, as well as encouraging experimental quantities of low-pattern-cost shapes. Inherently, shell molding is limited in intricacy as compared with investment, and limited in speed of first-part delivery as compared with baked sand.

The principal limitation of shell molding in comparison to sand casting of alloy steels has to do with patterns. Thin sections are more easily cast with shell molds than in any other way if the pattern is properly designed. But in the design of extremely thin parts, the shells must be made in two pieces to get enough mass to properly heat the sand and resin mix. Fig. 2 illustrates this point. There must be sufficient heat in the pattern to soften the resin and make it plastic, giving the sand a temporary bond until it is put into the oven and baked. Therefore, the pattern must be of such shape that there are no thin projecting areas with insufficient mass and heat content to make the resin plastic. In Fig. 3, the top step which is $\frac{3}{32}$ in. thick did not have sufficient mass to "set" an adequate shell (the average shell is between $\frac{3}{16}$ and $\frac{3}{8}$ in. thick), although the remainder of the pattern did. This was an experimental pattern to determine the minimum practical section and also to test various pattern materials.

Although the top step did not "set" an adequate shell, it illustrates the flexibility of this molding process. First, a good shell could have been formed by hand operations through the use of extra plastic, sand and heat. Second, if an automatic, long run job were involved, it would be possible to design part of the pattern for special heating to accommodate mechanization. Tests showed that cast iron, aluminum and brass are the best pattern materials, in that order; while copper, stainless steel and carbon steel are the least desirable.

As mentioned above, shell molds permit casting parts of great intricacy and complexity. An important limitation, however, compared with sand casting, arises from the fact that multiple piece, loose-part patterns are not practical in shell.

In sand casting, patterns can be made from many pieces of wood fastened by pins and removed separately after the sand has been rammed. In this way, complex shapes such as undercuts and backdrafts are possible. This technique does not lend itself to shell casting for several reasons. First, too much heat is lost while the pattern is being disassembled and reassembled for the next operation, and the change in temperature at critical points in the mold brings about variations in shell thickness. Timing is critical from one operation to the next in shell, but not in sand casting. In addition, the loss of heat with a multiple-piece loose-part pattern would be uneven, so that the thickness of the shell would vary. Second, shell patterns must be extremely accurate, so unless all parts of the pattern are held at the same temperature, assembly of the patterns would be difficult

Table I—Comparison of Shell Molding and Overlapping Processes

	Investment Casting versus Shell Molding	Baked Sand Casting versus Shell Molding	Precision Forgings versus Shell Molding	Welded Assemblies versus Shell Molding	Machined Parts versus Shell Molding
Overall Cost	Shell Cheaper	Baked Sand Cheaper	Forgings Cheaper	Shell Cheaper	Shell Cheaper
Degree of Complexity	Investment Better	Shell Better	Shell Better	Evenly Matched	Shell Better
Tooling Cost	Shell Cheaper	Baked Sand Cheaper	Shell Cheaper	Welding Cheaper	Hard to Compare
For Large Parts	Shell Better	Baked Sand Better	Forgings Better	Welding Better	Machining Better
For Small Parts	Investment Better	Shell Better	Shell Better	Evenly Matched	Machining Better
Life of Tooling & Pattern	Evenly Matched	Shell Better	Shell Better	Welding Better	Machining Better
Accuracy & Finish	Investment Better	Shell Better	Shell Better	Evenly Matched	Machining Better
Intricacy	Investment Better	Shell Better	Shell Better	Shell Better	Machining Better
Time for First Sample	Shell Better	Baked Sand Better	Evenly Matched	Welding Better	Machining Better
Dimensional Stability	Evenly Matched	Evenly Matched	Shell Better	Shell Better	Hard to Compare
Stress Distribution	Shell Better	Shell Better	Shell Better	Shell Better	Cannot Compare

or impossible. The accuracy of the final casting would also suffer as a result of uneven heat in various parts, and patterns at 500 F are too hot to handle except with bulky asbestos gloves. Precision handling is possible using mechanized methods, but the cost would be high. A third point is that the plastic in the shell would seep into the pattern and bond the parts together, making assembly and disassembly difficult, unless all parts of the pattern fit absolutely perfectly.

In general, a shell pattern should consist of very few pieces of metal. In casting intricate parts, it is preferable to make a number of separate shells from separate patterns and assemble them into the complete mold, rather than make one mold with many separate pieces in the pattern. This is not a basic disadvantage because it is possible to get very accurate register of the shell segments.

Backdrafts or undercuts are impossible in shell unless multiple shells are used. It is possible in shell molding to reduce the necessary amount of draft from the normal 3 deg to ¼ deg, which sometimes permits use of as-cast surfaces without machining.

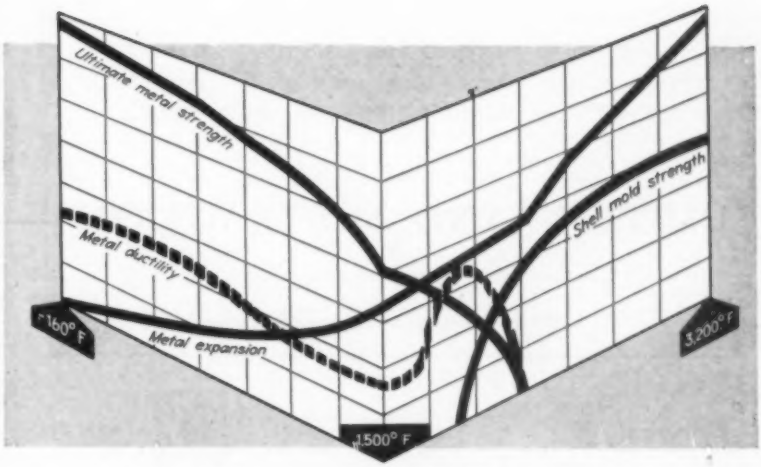
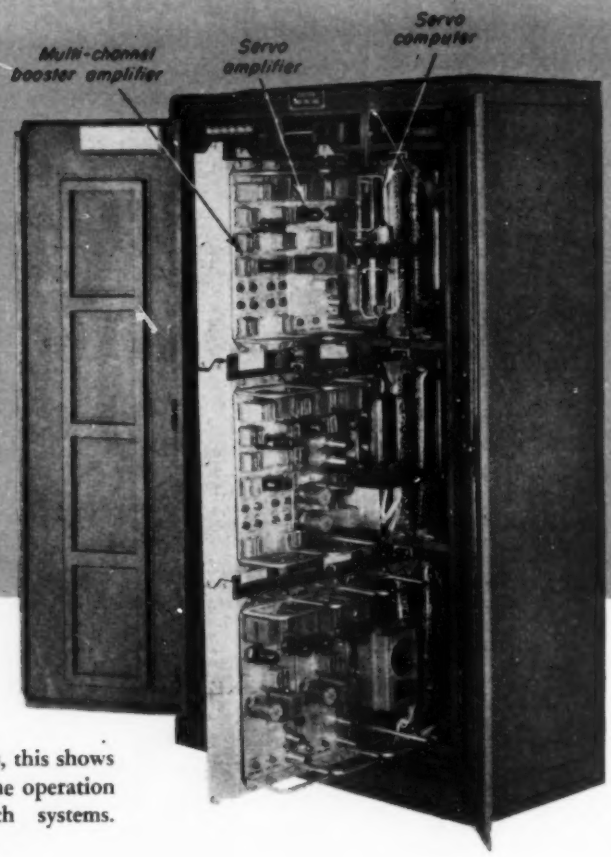


Fig. 4—Critical temperature range in which stresses are apt to develop in a shell molded part is between 1,500 and 2,600 F. Solidification occurs near upper end of this range.

The draft needed in conventional casting causes the thickness to increase 0.052 in. per inch, usually necessitating subsequent machining; the reduction to ¼ deg adds only 0.0044 in. per inch of thickness, which may be within a specified tolerance. In fact, it is possible in shell casting to make parts having a vertical wall measuring several inches with no draft at all.

It may safely be said that shell molding is a definite advance over other casting techniques in the production of stainless steel castings. Improvements are constantly being made so that this process will take its proper place in the broad field of casting.

Servo Systems for Performing



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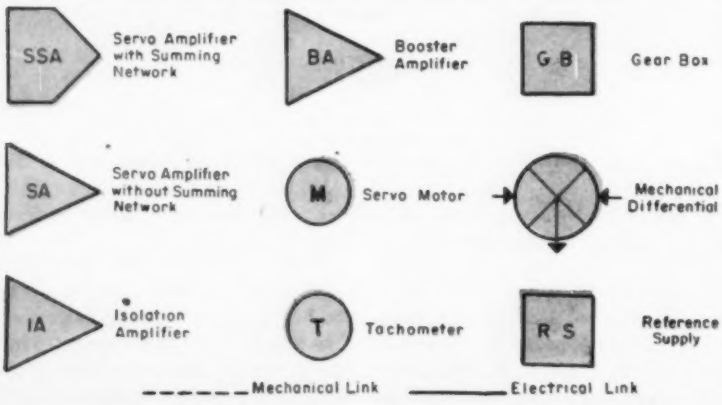
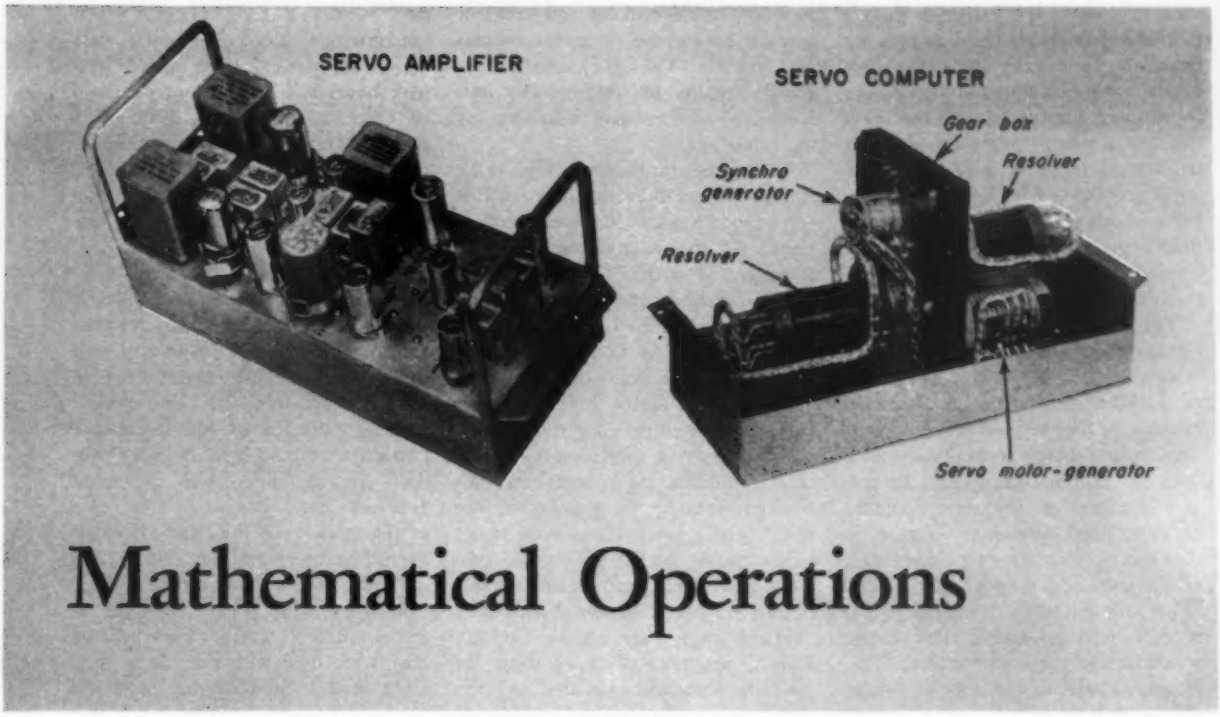
Based on work done in developing analog computers, this shows how servo circuits can be used without going into the operation and characteristics of the components of such systems.

ADDITION AND SUBTRACTION

Table I—Legend for Circuit Diagrams



Mechanical gear differentials are used extensively to add or subtract two quantities which are available at the same place as shaft rotations, the output appearing as a shaft rotation. If the input quantities are removed from each other, and the output sum is desired at a remote position, an adding servo can be used. A block diagram for such a unit is shown in Fig. 1(A). The equation it is solving is $X + Y - Z = 0$, which is mathematically equivalent to $Z = X + Y$. The error detector compares the output with the input and provides an error signal when there is a difference between the input and the output quantities. This difference quantity $X + Y - Z$, must be zero for a correct solution to the equation.



Mathematical Operations

ONE IMPORTANT CHARACTERISTIC of servomechanisms systems is that they afford a means of performing mathematical manipulations with physical qualities such as lengths, shaft rotations, voltages and currents. Basically, a servo is a torque amplifying system in which the output of the system, or some function of it, is fed back to be compared with the input. The difference between these two quantities, called the error, is then used to control the source of power. As such, it permits a designer to interconnect computation elements without producing loading effects which would tend to introduce inaccuracies. Among the operations that can be performed with servos are addition and subtraction, multiplication and division, powers and roots, triangle solution and integration.

Whenever it is not zero, the difference, or error signal is applied to the amplifier which in turn energizes the servo motor. The motor runs until the output Z becomes equal to the input $X + Y$. Then, the error signal is zero, and the motor stops. The solution of the equation is therefore available as a shaft position which can be fed into additional computers.

Typical components that may be used to make up this system are shown in Fig. 1(B). Table I is a legend to be used for proper interpretation of this, and the succeeding diagrams. Since detailed descriptions of the operation and characteristics of these components are available in the literature, only their functions will be discussed.

In Fig. 1(B), potentiometers are

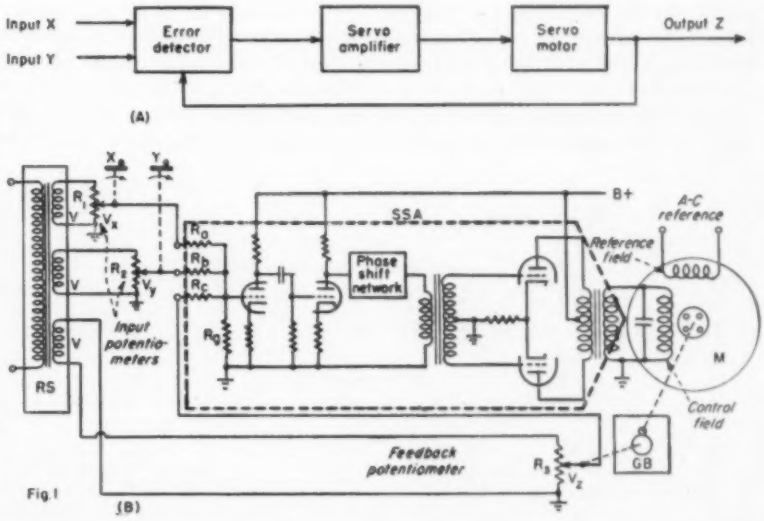


Fig. 1

used to convert the variables from a mechanical to an electrical nature. By impressing a voltage across the ends of the potentiometer and positioning its wiper in accordance with the input quantity, a voltage proportional to the mechanical input is available at the wiper contact. For computers, only potentiometers which have high resolution, good linearity and low noise are suitable. Either a-c or d-c may be used across them.

The amplifier has at its input a summing network consisting of the resistors R_a, R_b, R_c and R_g. This type of parallel resistor network is used extensively for the summation of voltages which have a common source with one terminal grounded. To prevent loading of the input potentiometers, with resulting decrease in conversion accuracy, the resistances of the summing resistors, R_a, R_b and R_c should be large compared to the potentiometer resistances. The voltage appearing at the common point "a" is proportional to the sum of the input voltages, $VX + VY - VZ$. Amplifiers which are used in servo systems must have enough power output to drive the servo motor and sufficient gain to obtain the desired computation accuracy. Thus, they usually have special circuits to improve the performance and prevent instability of the servo loop.

The motor illustrated in Fig. 1(B) is a two-phase induction motor which is commonly used for such applications. As shown, the control phase is connected across the secondary of the amplifier output transformer while its reference phase is connected to the supply. Ninety degree phase shifting networks are normally used in the amplifier. The motor drives the feedback potentiometer on the output shaft through a precision-type gear train. The direction of motor rotation is determined by the polarity of the error signal, which reverses on either side of zero. In the gear train, precision, fine-pitch gears insure smooth operation with minimum backlash.

Hand cranks are shown for the manual insertion of input data. In practice, automatic insertion of the data may be desired and additional servomechanisms can be used.

For adding angles, probably the most common method is one in which synchros are used as angular data conversion devices. The simple system shown in Fig. 2(A) uses a chain of three synchros, consisting of a synchro generator, synchro differential generator and a synchro control transformer. In such a system, an error signal exists whenever the displacement of the output shaft Z is not equal to the sum of the displacements of the two input shafts X and Y. A change of connections between the synchros makes it possible to have the motor drive the output shaft an amount equal to $X - Y$. This method may be extended to add more than two shaft rotations by using more than one synchro differential generator. Inherent static inaccuracies in each of the synchros of the chain affect the overall accuracy of the system. To minimize the synchro errors, a multiple-speed system can be used as shown in Fig. 2(B). Two synchro chains are used with one chain operating at the speed of the input and output shafts and the other at a higher speed, say 15 times higher. For a 15:1 system, one degree error in the

MULTIPLICATION AND DIVISION

A bridge circuit similar to the one discussed above is also useful for multiplying and dividing. In the bridge illustrated in Fig. 4, a servo is used for automatic balancing. At balance, $R_1R_3 = R_2R_4$ or $\theta = XZ/Y$ where X, Y and Z are the known input parameters. In this form, the bridge provides an output that is the product of two inputs divided by a third input. However, by keeping R_3 (that is, Y) constant, multiplication of X and Z is performed, and by keeping R_3 (that is, Z) constant, division of X by Y is performed.

Another method of multiplication is illustrated in Fig. 5. Input potentiometer R_a is excited from a constant voltage supply. Its wiper is turned through an angle proportional to the quantity X to be multiplied. Potentiometer R_b is excited by the output of the input potentiometer (via a high input impedance isolation amplifier to prevent loading of the input potentiometer) and its wiper is turned through an angle proportional to the second quantity Y. The output of potentiometer R_b (VXY) is proportional to XY which is compared with the output of the feedback potentiometer $R_c(VZ)$. The difference signal is amplified in the servo amplifier controlling the motor. The motor drives until the error signal $VXY - VZ = 0$, at which time $VXY = VZ$ or $XY = Z$. Therefore, the product XY is given by the total amount of rotation of the output

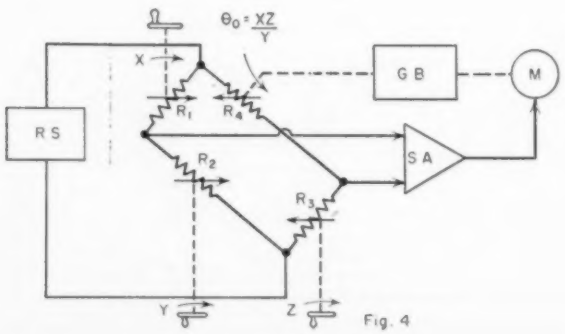


Fig. 4

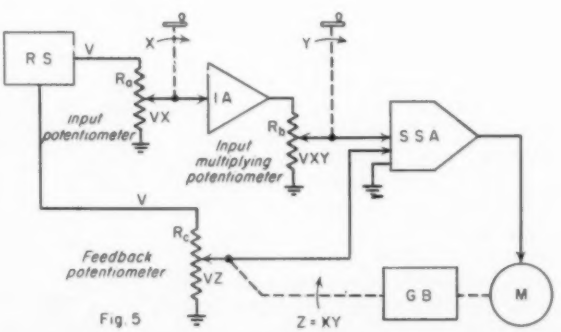
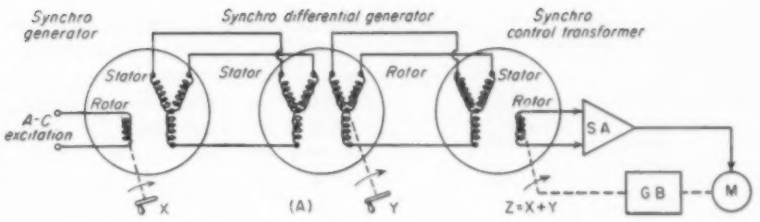


Fig. 5

higher speed (controlling) synchros is equivalent to 1/15 degree error in the position of the output member. The servo system is controlled by the error signal developed in the high speed synchro system which acts as a vernier on the slow speed synchro system. Synchronization of the two synchro chains is necessary for proper operation.

Another addition method is shown in Fig. 3. A servomechanism is used to balance automatically the resistance arms of a bridge circuit. The input shaft rotations X and Y set the resistances of the two linear resistors R_1 and R_2 in one arm of the bridge. R_4 and R_5 are fixed resistors which are usually equal. The value of the linear resistor R_3 is set by the amount of rotation of the servo motor. An error signal appears between points a and b whenever the bridge is out of balance. This error signal is applied to the amplifier controlling the motor. The motor drives until the error signal is zero, balancing the bridge. At balance:

$R_3R_4 = (R_1+R_2)\,R_4$
or $R_3 = (R_1+R_2)\,R_4/R_5$ and since $R_4 = R_5$
$R_3 = R_1+R_2$ or $Z = X+Y$.



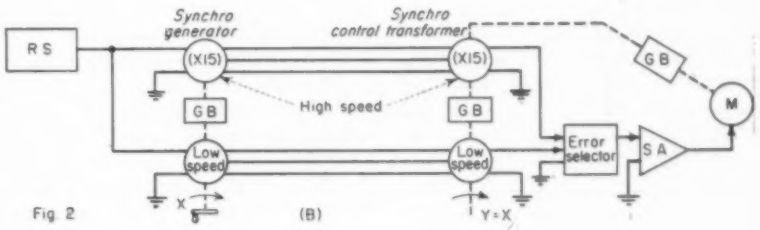


Fig. 2

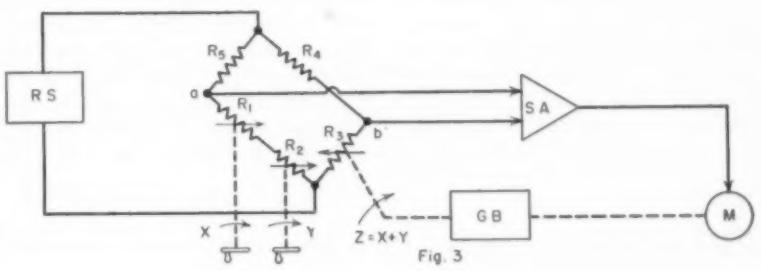


Fig. 3

shaft. If the resistance of R_a is small compared to that of R_b, the isolation amplifier may be omitted.

The circuit in Fig. 6 shows how the interconnection of the components of the multiplying servo described above can be rearranged to accomplish division. Since $YZ - X = 0$ is mathematically equivalent to $Z = X/Y$, division may be performed by a computing system that continuously solves the equation $YZ - X = 0$.

A mechanical device which is used extensively in analog computers is the ball-disc integrator which can readily be adapted for multiplication, division, squaring, integration and differentiation. As shown in Fig. 7(A), it consists of a disc, two balls in a carriage which can be positioned anywhere along the disc, and an output cylinder. The balls are in contact with the disc and cylinder and are used to transmit motion from the disc to the cylinder. The amount and direction of rotation of the output cylinder depends upon the amount and direction of rotation of the input disc and the amount and direction of displacement of the balls along the disc. As a mechanical multiplier, one input is the rotation of the disc, and the other the position of the ball carriage, the output product being the rotation of the cylinder.

If the load on the output cylinder is excessive, slipping will occur and the accuracy of computation will be decreased considerably. To prevent

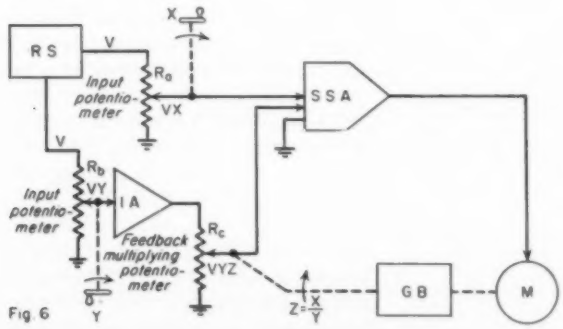


Fig. 6

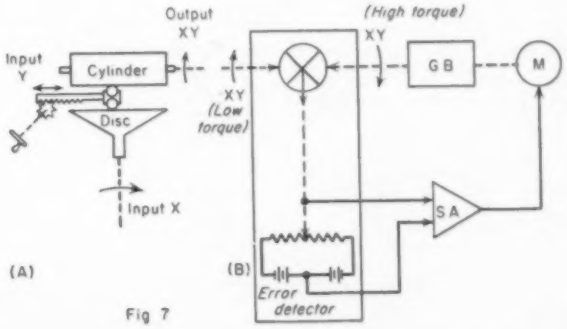


Fig. 7

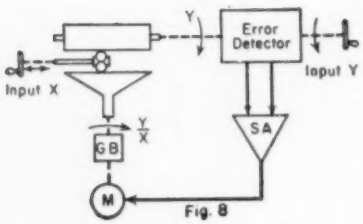


Fig. 8

such loading and to multiply the torque output of the ball-disc integrator, a servo follower is normally used. Fig 7(B) illustrates one type of follow-up which has a mechanical differential and potentiometer as an error detector. As shown in the diagram, the input shaft drives one side of the mechanical differential and the output shaft drives the other. When there is any difference between the input and the output shaft rotations, the spider of the differential rotates the wiper of the potentiometer providing an error signal for the servo amplifier. The amplifier output controls the motor in such a way as to reduce the error to zero. This type of follow-up provides torque multiplication without excessive loading since the only load imposed on the cylinder is that of the error detecting device. However, it is useful only in applications where the input and output are located together. If the output of the integrator is required at a different location, a system of the type in Fig. 2(B) may be used, with the synchro generator rotor mechanically coupled to the integrator roller.

An interesting application of a ball-disc integrator and follow-up servo for dividing is shown in Fig. 8. The balls of the integrator are positioned by one input, X, and the other input, Y, feeds into one side of a device which compares this Y input with the roller output. Whenever they are not the same, an error detector, similar to the one described in the preceding paragraph, provides an error signal which is used to control the motor driving the disc.

POWERS

The multiplication method illustrated in Fig. 7 can be extended to provide second, third and higher powers of a parameter by the use of two or more such units in series and repeating the multiplication with the parameter. Fig. 9 shows how two ganged potentiometers R_a and R_b are used to obtain the square of an input shaft rotation.

A ball-disc integrator can also be used to square a quantity available as a shaft rotation. The input X is arranged to drive the disc as well as to provide the displacement of the ball carriage. The output being the product of the disc and ball carriage displacement is therefore equal to X^2.

The diagram in Fig. 9(B) illustrates how ganged-potentiometers may be used with servomechanisms to produce roots. In this example, the

TRIANGLE SOLUTION

A problem often met in analog computation is that of solving right triangles. When the hypotenuse and a side of a right triangle are known and the other side is required, a bridge-type computer which solves the relation $(X + Y)(X - Y) = Z^2$ is used. If X and Y are shaft rotations, mechanical differentials are used to get $(X + Y)$ and $(X - Y)$ as shaft rotations as illustrated in Fig. 10. These are used to set up resistances R_a and R_b in opposite arms of a bridge circuit proportional to $(X + Y)$ and $(X - Y)$. The bridge is completed by ganged potentiometers R_c and R_d in the other two arms whose common shaft is servo driven. At balance: $R_aR_b = R_cR_d$ or $(X + Y)(X - Y) = Z^2$ making the unknown side Z available as a shaft rotation.

The solution of a right-angle triangle for its hypotenuse, given its two sides, requires a computer which will solve the equation $X^2 + Y^2 = Z^2$ where Z is the hypotenuse. The quantities X and Y are squared and added and the result is fed into a device that extracts the square root, since $Z = \sqrt{X^2 + Y^2}$. A voltage proportional to the square of an input shaft rotation is obtained by the multiplication technique described previously. In the computer shown in Fig. 11, ganged potentiometers are used to obtain voltages proportional to X^2, Y^2 and Z^2 and a servo loop is used to solve the equation $X^2 + Y^2 - Z^2 = 0$. In so doing, the output shaft rotates through an angle equal to Z, the unknown quantity.

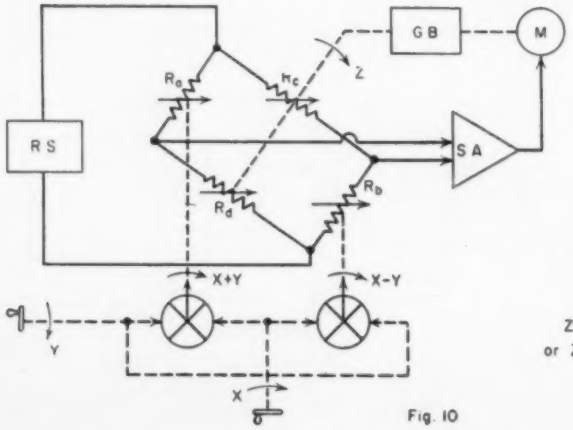
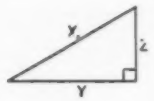


Fig. 10



$Z^2 = X^2 - Y^2 = (X+Y)(X-Y)$
or $Z = \sqrt{(X+Y)(X-Y)}$

The most widely used method of right-angle triangle solution uses an electromechanical device called a resolver. A resolver alone may be used to convert polar to rectangular coordinates and, in conjunction with a servo, to convert rectangular to polar coordinates. In performing the latter operation, it is actually solving for the hypotenuse and angle of a right-angle triangle. Fig. 12(A) illustrates how a resolver performs the trigonometric operation of resolving a vector quantity into its sine and cosine components. A voltage proportional

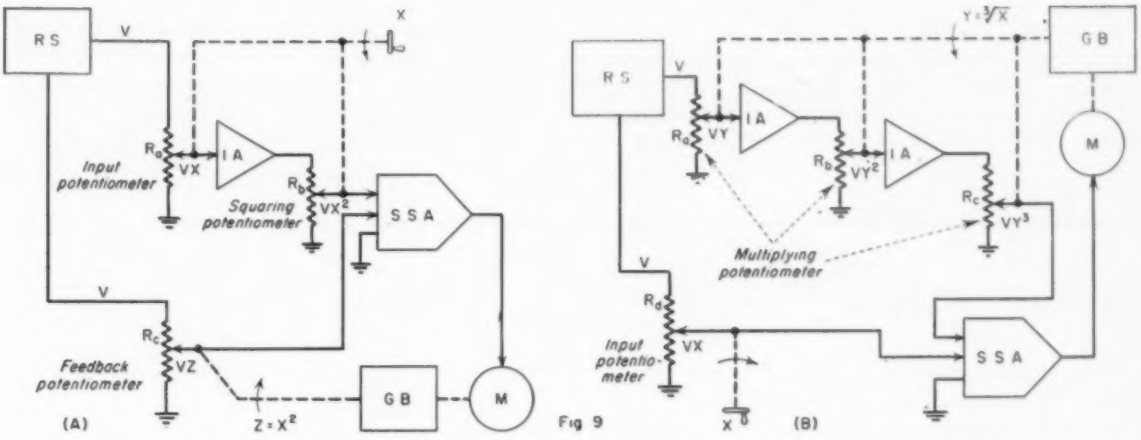


Fig. 9

cube root of an input quantity which is available as a shaft rotation X, appears as a shaft rotation. R_a, R_b and R_c are linear, equal-resistance, ganged potentiometers driven by the servo motor. The input quantity, voltage VX, is summed with the voltage fed back from potentiometer $R_c(VY^3)$, and the difference voltage is amplified by the servo amplifier. The servo motor rotates until the error signal is zero, or until the output voltage VY^3 is equal to the input voltage VX. Since $VY^3 = VX$, $Y^3 = X$ or Y is equal to the cube root of X.

to the vector is impressed across one of its rotor windings with the other rotor winding short-circuited. The output stator voltages are proportional to the input voltage times the sine and cosine of the angle between the axes of the rotor and stator windings, that is, the resolver shaft angle.

The servomechanism represented by Fig. 12(B) illustrates how a resolver can be used to find the hypotenuse Z and angle θ of a right-angle triangle whose sides X and Y are known. Voltages proportional to the sides X and Y are impressed across the two stator windings. Under these conditions the voltages induced in the rotor windings are $VX\cos\theta + VY\sin\theta$ and $-VX\sin\theta + VY\cos\theta$. The later rotor voltage is used as the input to the amplifier feeding the servo motor which drives the resolver rotor. Since the servo loop will reduce its actuating signal to zero,

$$-VX\sin\theta + VY\cos\theta = 0 \text{ or}$$

$$VY\cos\theta = VX\sin\theta.$$

Therefore, $\theta = \arctan Y/X$, where θ is the rotation of the rotor shaft. Under null conditions, the voltage $(VX\cos\theta - VY\sin\theta)$ appearing across the other winding is equal to

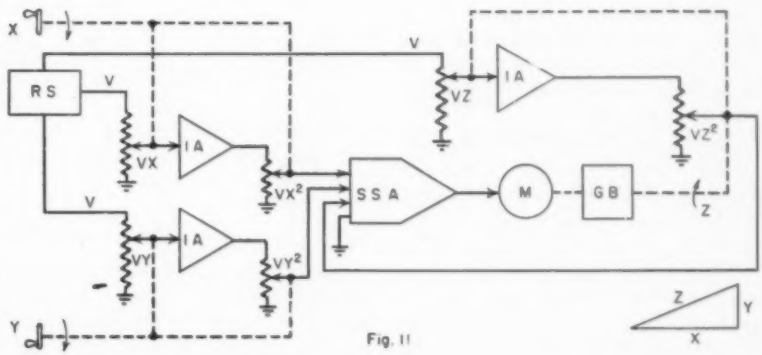


Fig. 11

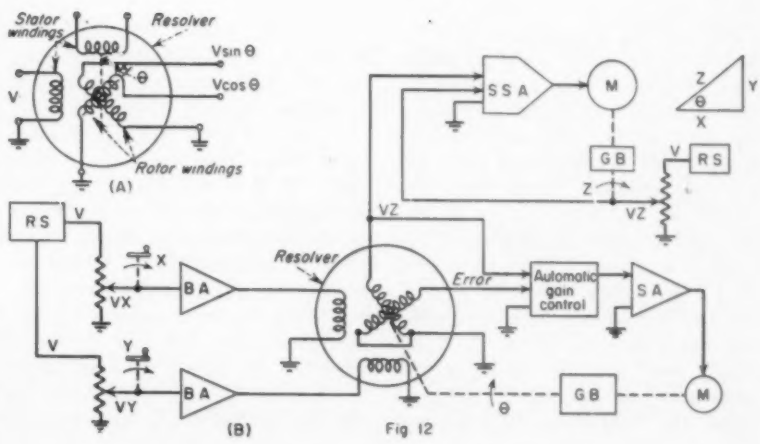


Fig. 12

$\sqrt{X^2 + Y^2}$, the hypotenuse, Z, of the triangle. To obtain Z as a shaft rotation, a second servo loop is added as shown.

In the proper design of a resolver type system, consideration must be given to a number of factors, which are peculiar to such a system, if the highest possible computational accuracy is desired. Special high gain feedback amplifiers (booster amplifiers) are used in the stator circuits to prevent loading of the driving elements (input potentiometers) in Fig. 12(B). In addition, these amplifiers usually include networks for resolver stator to rotor phase shift and voltage ratio adjustments. The servo amplifier which amplifies the resolver error signal is usually an amplifier whose gain automatically varies inversely with the magnitude of the stator voltages. This is necessary to keep the torque sensitivity, restoring torque per degree displacement of rotor, of the servo loop reasonably constant for all normal values of the stator voltages.

INTEGRATION

The ball-disc device previously described under multiplication and division finds its widest application as an integrator. It can be used to integrate a quantity with respect to an independent variable when these quantities are available as mechanical inputs. It is particularly useful in applications where the independent variable is some quantity other than time. As illustrated in Fig. 13(A), for a rotation of the disc equal to dX and a ball displacement of Y, the YdX is obtained at the roller. To obtain good accuracy there must be no slippage between the roller and balls due to loading of the roller, and to ensure this, a servo type torque multiplier is usually used.

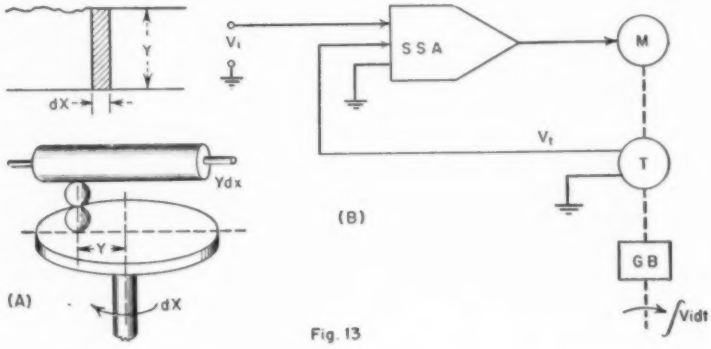


Fig. 13

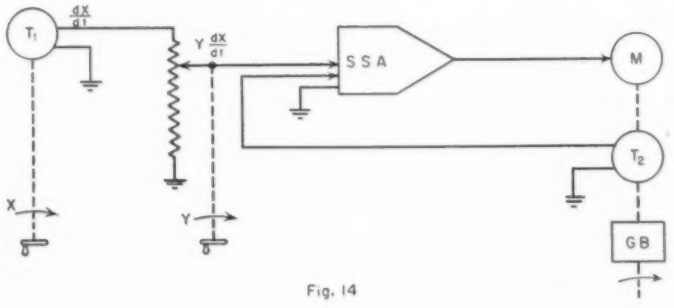


Fig. 14

Fig. 13(B) illustrates an integrator in which the integral of a quantity with respect to time is obtained as a shaft rotation. This is called a velocity or rate servo. It consists of a tachometer or rate generator, servo motor and an amplifier interconnected as shown. The tachometer is an electromagnetic device that produces a voltage proportional to the speed at which it is driven. The voltage to be integrated, V_i, is compared with the tachometer voltage, V_t, and the difference or error signal is amplified in the high-gain amplifier controlling the servo motor. The motor runs at a speed that maintains this error signal at a minimum. Under these conditions, V_t is nearly equal to V_i and the total amount of rotation of the motor is a measure of the time integral of V_i. In such a servo, the gain of the amplifier is set as high as possible, for the higher the gain, the more nearly equal will be the input and tachometer voltages and the more accurate the integration. Both a-c and d-c tachometers have been used in velocity servo applications. In general, the type of tachometer chosen depends upon the characteristic of the voltage to be integrated, whether a-c or d-c.

A velocity servo which can be used to provide a shaft rotation that is an integral of one quantity with respect to another quantity other than time, is shown in Fig. 14. Here, both quantities X and Y appear as shaft rotations. If X is the total rotation of the tachometer T_1, the voltage output of the tachometer is dX/dt which after multiplication by Y in the potentiometer, is compared with the output voltage from tachometer T_2, the difference being fed into the servo amplifier. As before, the total output of the rate servo is proportional to the time integral of the input voltage. Thus it is: $\int Y\,(dX/dt)\,(dt)$ or $\int Y dX$. This integrator performs the same function as the ball-disc type unit. However, it does not require a torque multiplier servo, and is useful where the input and output motions must be remotely located.

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Keeping Track of Projects with Control Boards

For the average size engineering department of less than a hundred people, considerable time is saved and delivery dates met when the current and overall status of an engineering project can be quickly and accurately determined.

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North Hollywood, Calif.

THE NATURE of project scheduling and control deals with time, both calendar and quantitative, and the nature of engineers makes them more concerned with results than with time. Other factors evolve from the human tendency to lean toward those activities that hold the greatest interest. Thus, when a design reaches the stage where the loose ends must be tied together, it takes on the aspects of a chore and is in danger of being neglected.

One piece of machinery aimed at alleviating this situation is a control board, which tells at a glance the status of a job and its promised completion date. Many boards have been tried and probably no two are alike because each engineering group that uses one has problems peculiar to its specific operations.

To classify engineering groups by size, those with less than 10 men might be regarded as small, those from 10 to 100 as medium, and those with more than 100 as large. Usually a small group is a closely knit organization that is well acquainted with manufacturing and sales requirements. Probably the number of active engineering jobs in small. As a result, the control board for a small engineering department might well prove to be more trouble than it is worth. At the other extreme, the large engineering group can and does justify special control boards for specific and limited operations. Here a group of specialists manipulate the boards. But the highly representative medium size engineering group requires a mechanism that is more versatile and can cover a wide range of activities.

A Chief Engineer can readily keep track of the activities of five engineers who may be handling a total of twenty active jobs. The engineers in turn are able to keep in touch with the Chief and have a clear understanding of what is required and when it must be completed. Such a group can operate effectively and flexibly with a minimum of established procedures and red tape. However, as the engineering staff is increased, additions must also be made in the drafting and related activities. By the time the engineering force is up to ten, the Chief is unable to spend as much time with each engineer and, as a result, each must depend on his own judgment for the "what" and "when" of projects. Such a situation can be corrected or avoided by establishing a system of controls and priorities as tools for meeting due dates.

The basis for any realistic schedule must be the initial estimate of the amount of time required, the number of men required and when these men will be available. The accuracy of such a schedule can be no more accurate than these estimates. At its best, this operation is more of an art than a science; at its worst, it is a frustration for all concerned.

The factors that contribute toward

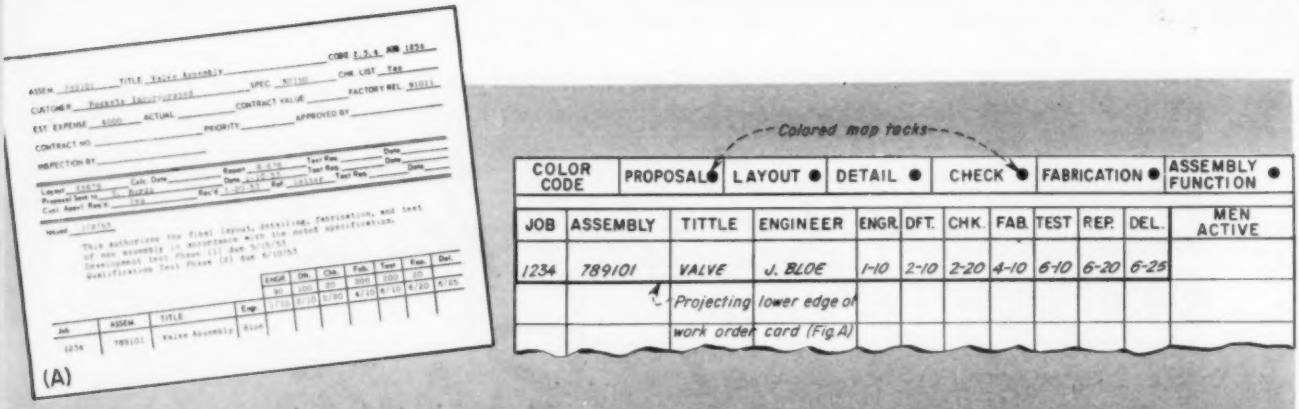


Fig. 1—Headings across top of control board are coded with colored map tacks so that progress of engineering jobs can be plotted along calendar at right. Lower deck of headings at left is actually bottom of engineering work order card in flip-up type Kardex file holder. (A) Engineering work order card describes job and, as noted, authorizes various phases in life

this situation are many and varied. There is the engineering problem itself for which the results desired must be clearly stated. This is a matter of examining the facts and figures in a consistent and systematic manner. But when the personnel available for the project are considered relative to target dates, the clean-cut area of facts and figures begins to blend into an atmosphere hazy with elements such as personalities, health problems and all the other unpredictables.

The estimator for a large engineering activity has a useful tool in the statistics he can apply. If enough people are involved, many of the personality problems will average out so that the percentage of error attributable to this factor is not unreasonable. In a small engineering group the estimator—usually the Chief Engineer—has a thorough knowledge of the personalities and capabilities of this group. This gives him a fairly accurate picture of what he can expect each man to produce within a given time. The estimator in a medium size organization is caught somewhere in between. His group is too small for the statistical tool to be accurate, and too large for him to be well acquainted with each individual.

The Hydraulic and Electro-Mechanical design department at Bendix, Pacific Division falls into the medium size class. During an extended period of expansion, all of the standard growing pains were experienced. In addition to the design and drafting function, this group now includes a Model Shop and laboratory facilities for complete qualification testing.

The engineering responsibilities of this group are more or less typical. Work authorizations are originated in the Sales Department and forwarded along with the job requirements and specifications to Engineering. The first phase of engineering is to study the requirements and prepare a design proposal which is returned through Sales to the customer. After the proposal has been reviewed by the customer and perhaps modified for his final approval, the design is returned to the engineer for the final layout and detail analysis. After layout approval, the job progresses to the detail drafting, through checking and corrections for experimental release. When all required parts have been approved by Inspection, they are sent to the engineering laboratory for assembly and test. Uusually, the tests have two phases. First, there is a development period when the function bugs are worked out. The second phase is used for demonstrating the capacity of a production prototype to meet all of the customer requirements. A final report is then prepared to verify qualification compliance.

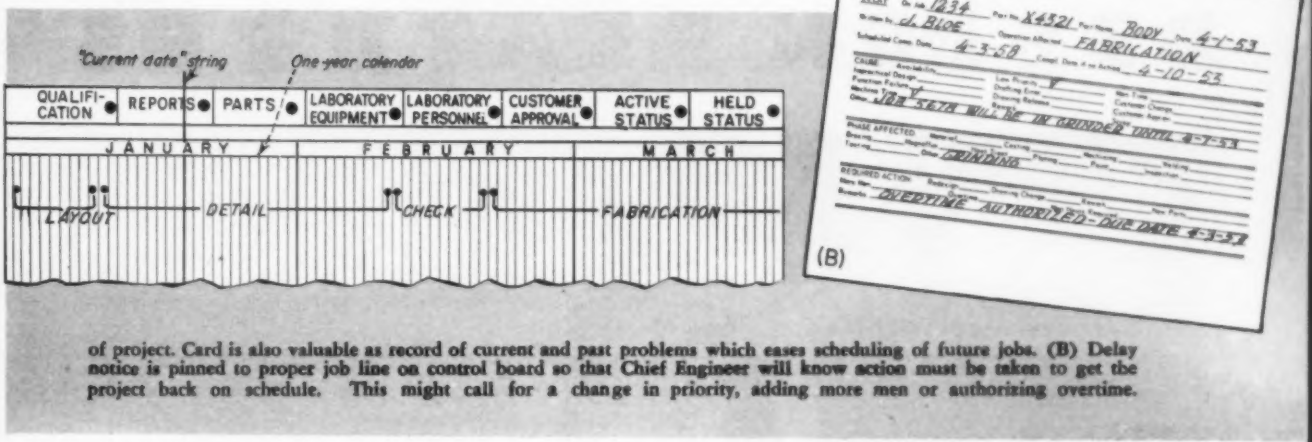
This sequence of events points up the fact that scheduling control is complicated by a job moving from one phase and type of work to another. There are inevitable delays of a few hours to a few days between operations. These are the result of juggling men from one job to another. It is impractical to exactly coincide the end of one operation with the beginning of the next when as many as 100 different projects are in simultaneous operations. In addition, there are phases over which Engineering has no direct control timewise.

When the engineering operations at Bendix had compounded to the point where a detailed system of schedule control was necessary, several techniques were considered. At first, each Project Engineer had full responsibility for the progress of his job during the time it was an engineering function. Each job had a project book in which all pertinent design data and a running account of the job status were entered. Periodically, the project books were submitted to the Chief Engineer to acquaint him with the progress of the work. This system had three flaws: it took too much of the Chief Engineer's time, the type of information and method of entering comments were highly erratic because they reflected the individuality of each engineer, and it was a full-time job getting the engineers to take good notes.

Another system was tried wherein individual engineers were asked to present verbal reports. The Chief Engineer reviewed these reports and made his own comments on file cards. This system gave consistent and complete reports, but was too time consuming.

After considering several different arrangements for a control board, the one shown above was put into use. Because of the variety of the projects, a prime requirement was that the board be flexible to operate. The anticipated modifications of schedules discouraged the use of colored or coded lines that would require erasing. This also discouraged use of the standard but relatively expensive boards available for such an operation.

The board consists of a piece of plywood covered with cream colored



of project. Card is also valuable as record of current and past problems which eases scheduling of future jobs. (B) Delay notice is pinned to proper job line on control board so that Chief Engineer will know action must be taken to get the project back on schedule. This might call for a change in priority, adding more men or authorizing overtime.

linoleum. Across the board horizontally, Fig. 1, is a one-year calendar; vertically there is space for ninety-three jobs. Attached to the left side of the board are card holders from a Kardex file. These are arranged so that the display area of a job log card coincides with a horizontal job line extending across the calendar. At the top of the board is a color code which indicates the various job operations. Ball-ended map tacks with colored tops are used to bracket the time scheduled for each operation.

When a job is issued, it is accompanied by an *engineering work order* on a Kardex file card, Fig. 1(A). This card completely describes the job requirements and indicates the estimated number of hours for each operation and the scheduled due date. The card is placed on the board and the pertinent due dates established on the calendar by bracketing the starting and completion dates with the map tacks. A large green tack indicates the actual status of the job by showing the last date when a log note was made by the engineer. In the event that a job is stopped, this green pin is replaced by a red pin on the date of stoppage.

A red string mounted vertically represents the current date. If the gap between this string and the active-status pin becomes too great, it is immediately apparent that a log note is overdue and the job may be suffering from neglect.

Often it is desirable to indicate due dates for phases within a basic operation. This is particularly true on development jobs where several months may be reported in a Phase I design study, followed by a Phase II preliminary layout and a Phase III final layout. Such a situation is readily handled by attaching a small paper flag to the pin with a notation of Phase I, Phase II, etc. Another use for the flag is to show a short production run of parts with a staggered delivery. The appropriate pin is entered on the due date with a flag indicating the quantity of units to be delivered at that time.

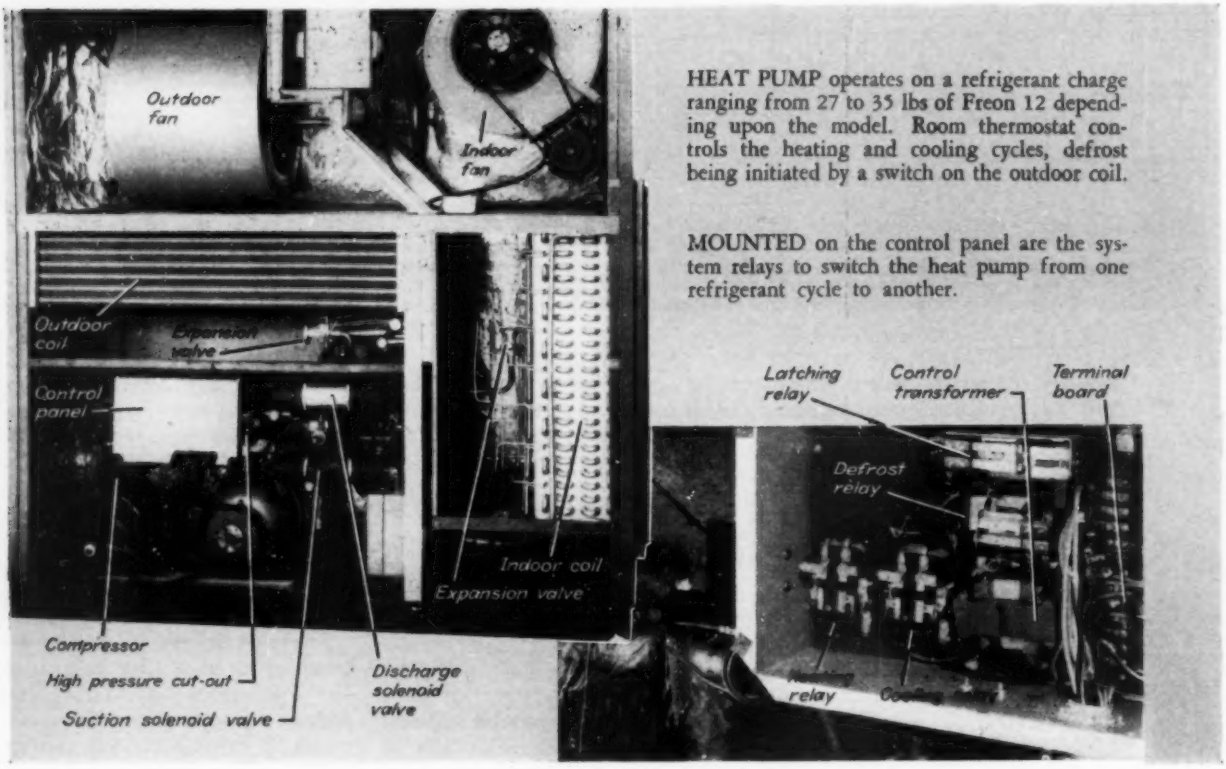
Another auxiliary tool is the *job delay notice*. Any time it becomes apparent to the responsible engineer that he is not going to be able to meet his due dates within the limits of his authority, it is his responsibility to fill out a *job delay notice*, Fig. 1(B), and to pin the notice on the proper job line. This serves as a flag to the Chief Engineer who can take corrective action by changing the priority of the job, adding men, authorizing overtime or re-scheduling. When corrective action has been taken and noted in the log, the delay notice is removed from the board.

The value of the log card should not be underestimated. It not only serves as a standard form for outlining the project requirements, but is a running record of the problems encountered and a history of any reasons for delay. It also records all pertinent correspondence and reference material. As a result, at some future date when a similar job may be in the mill, a new engineer has only to collect the information and review the history of this and other jobs to avoid repeating mistakes.

No control board has value unless it is kept in focus so that it presents an accurate and reasonably current picture. The two basic failings that undermine the usefulness of a control board are *inadequate follow-up* and *inaccurate follow-up*. With the former, the responsible person simply does not know the status of his job; with the latter, he coasts along with reports indicating his work is on schedule until the due date when his work is found to be half finished.

Several techniques for keeping the board up to date have been tried. The first attempt was to have each project engineer follow his assignments by keeping his log and the board in focus during the entire period when the job was a department responsibility. In many cases this worked well, but it was never consistent. Some of those who were consistent on the great majority of their jobs would occasionally "lose" a job. Others would follow-up thoroughly for perhaps a week and then gradually let the board fade from their concern. Perhaps the greatest problem was again the log notes. This was the result of each man having his own individual conception of what constituted a complete, concise and properly presented notation.

The present arrangement utilizes the services of one trained engineer for the entire board. This is producing satisfactory results, probably because one person can work more closely on a complex and constantly changing problem than can several people. Though it is hard to analyze the value of a control board, it is sufficient to say that operations which are difficult to control with the board would be close to impossible without it or a similar mechanism.



HEAT PUMP operates on a refrigerant charge ranging from 27 to 35 lbs of Freon 12 depending upon the model. Room thermostat controls the heating and cooling cycles, defrost being initiated by a switch on the outdoor coil.

MOUNTED on the control panel are the system relays to switch the heat pump from one refrigerant cycle to another.

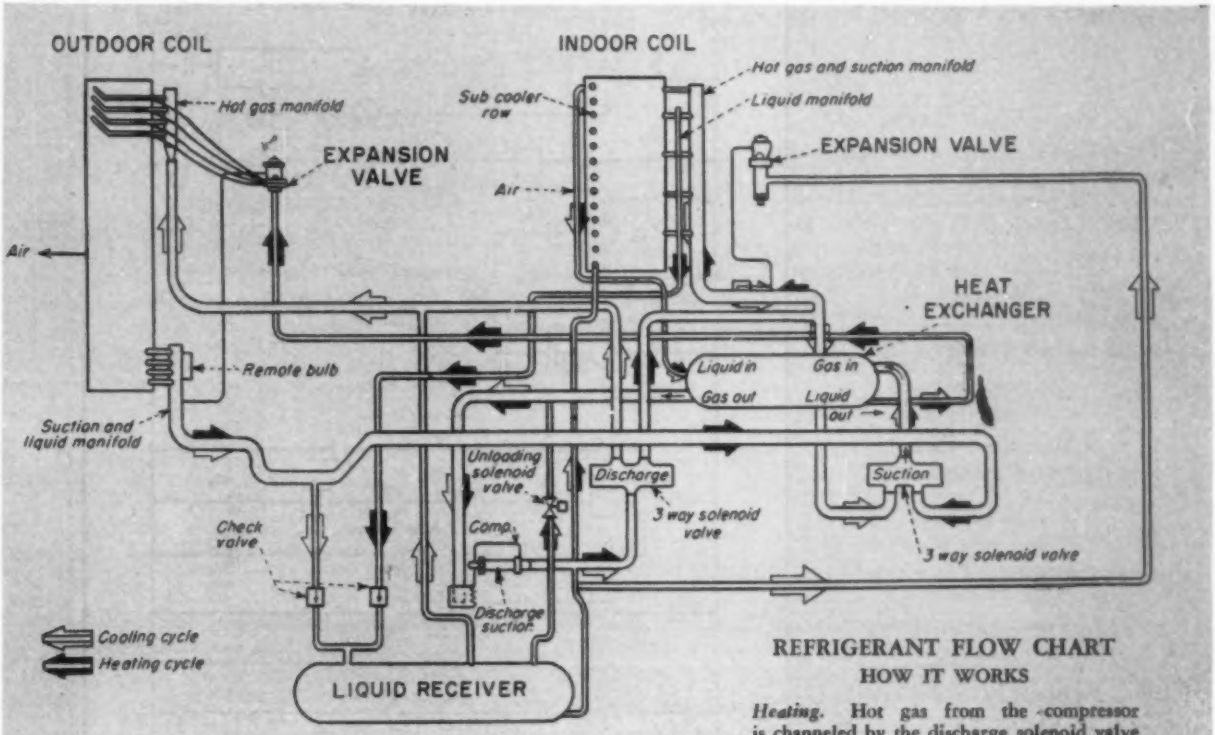
Solenoid Valves Channel Heat

Essentially an oversized refrigeration system, General Electric's heat pump—designed to replace conventional heating and cooling units—operates on the same principle as any refrigeration system using a thermostatic expansion valve and an air-cooled condenser. But an unique electrical control system makes the heat pump practical by positioning two three-way valve solenoids in the suction and discharge lines to make the indoor and outdoor coils perform dual operations. During the heating cycle, the indoor coil acts as a condenser and the outdoor coil, an evaporator. During cooling, the outdoor coil condenses the refrigerant, and the indoor coil performs as an evaporator.

Primary control over the pump operation is a combination heating and cooling thermostat consisting of separate electrical circuits for initiating the heating and cooling cycles. The thermostat is connected to a special relay arrangement which functions to position the three-way valves for either the heating or cooling refrigerant cycle, depending upon the demand from the room thermostat.

Most of the control equipment used are standard types. All the relays employed are stock items with the exception of a "memory" relay in the control panel. This relay has two operating coils and a mechanical latch set between the two armatures. Function of the latch is to hold an armature in the position set by the coil last energized, thus maintaining the former operating cycle of the pump after power has been removed from the relay. It's position only changes when the room thermostat signals for a change in the operating cycle. This insures a rapid response in heating or cooling demands without constant cycling of the compressor.

Included in the electrical system are controls to auto-



Pump Refrigerant

matically defrost the outdoor coil. The defrost cycle is actuated by a switch which detects an increased pressure drop over the coil resulting from a frost or ice build-up on the coil. A pressure switch in the defrost circuit gives a flexible defrost cycle to assure complete frost removal under all conditions and sensing switch settings. During this time the pump operates on the cooling cycle allowing the heat in the hot gas to melt the frost or ice. Defrosting starts with stopping of the outdoor fan.

Refrigerant that is channeled to either the indoor or outdoor coils passes through conventional thermostatic expansion valves with equalizer connections before entering the coils. Built into the indoor coil is an additional over-riding bellows which acts to throttle the flow through the valve. This action prevents the head pressure from rising above the cut-out point of the high pressure switch with frequent cycling of the pump.

REFRIGERANT FLOW CHART
HOW IT WORKS

Heating. Hot gas from the compressor is channeled by the discharge solenoid valve to the indoor coil. Indoor air passing over the coil absorbs the latent heat of vaporization when the Freon 12 condenses and cools. Warmed air obtained is then used for heating the home. From the indoor coil, the liquid refrigerant flows through a check valve to a liquid receiver and then through the subcooler row where additional heat is made available to the indoor air. Flow continues through the heat exchanger to an expansion valve on the outdoor coil which evaporates the Freon by extracting heat from the outdoor air passing over the coil. The gas now flows to the suction solenoid valve which channels it to a heat exchanger and back to the compressor.

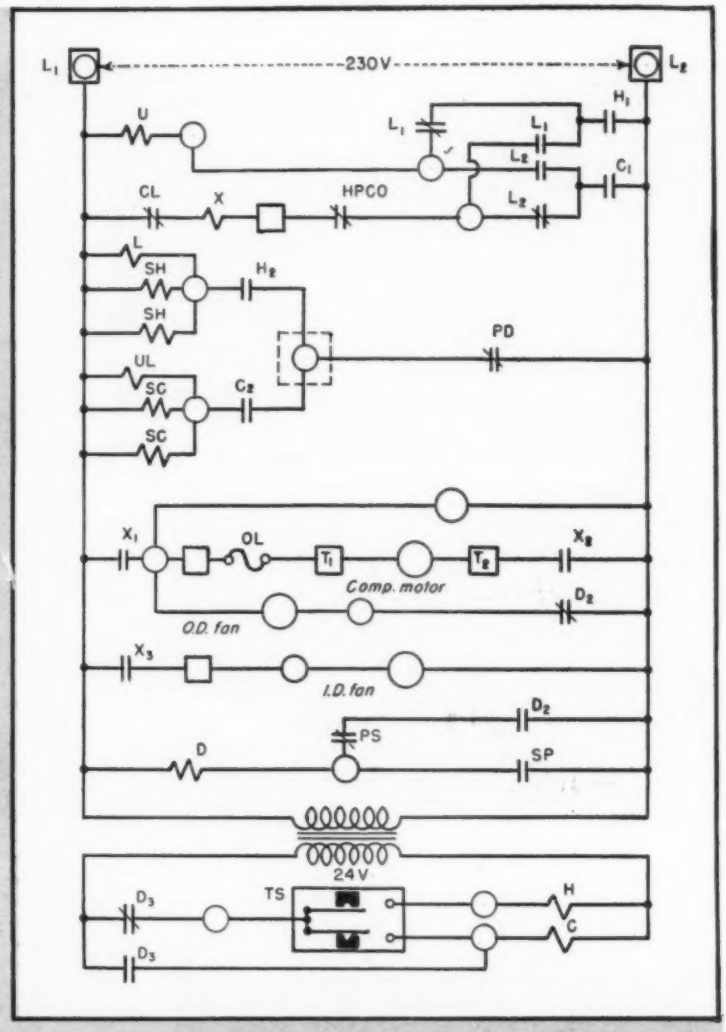
Cooling. Discharge solenoid valve channels the hot gas from the compressor to the outdoor coil where the refrigerant is condensed by the outdoor air passing over the coil. Liquid freon collected in the coil flows into the liquid receiver and then into the expansion valve of the indoor coil. The refrigerant is metered into the coil and in evaporating, cools the inside air passing over the coil. This air is used to cool the home. Leaving the indoor coil, the gas flows back to the suction solenoid valve and is channeled to the heat exchanger and to the compressor.

Defrost. The heat pump operates on the cooling cycle, allowing the hot gas to melt the frost or ice on the outdoor coil.

Refrigeration System (continued)

PD-PRESSURE DIFFERENCE SWITCH

HPCO-High press. cutout
L-Latching relay
OL-Overload relay
U-Unloading valve
UL-Unlatch coil latching relay
SC-Switchover valve cooling
SH-Switchover valve heating
SP-Static press defrost switch
PS-Defrost pressure switch
X-Comp. motor starter
TS-Thermostat
H-Heating relay
C-Cooling relay
D-Defrost relay
○-Represents control box terminals
□-Represents magnetic starter terminals

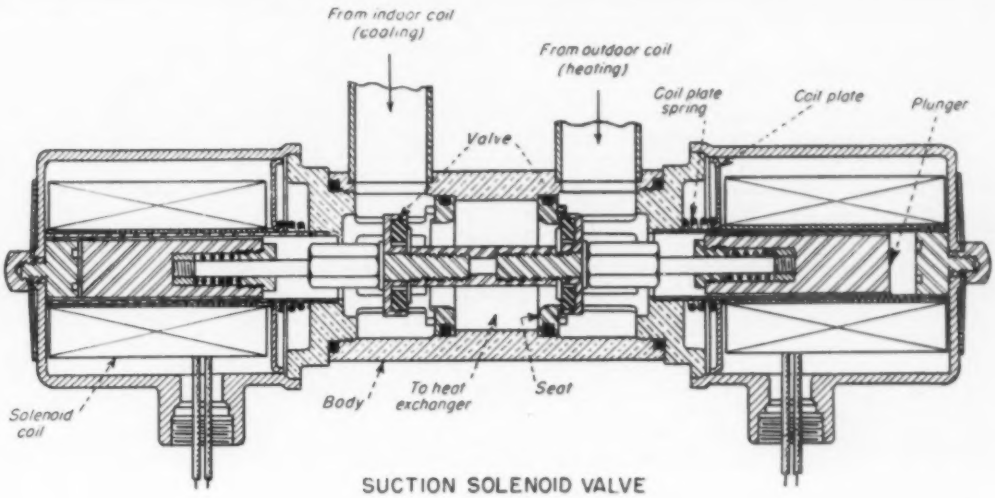


HOW THE ELECTRICAL SYSTEM WORKS

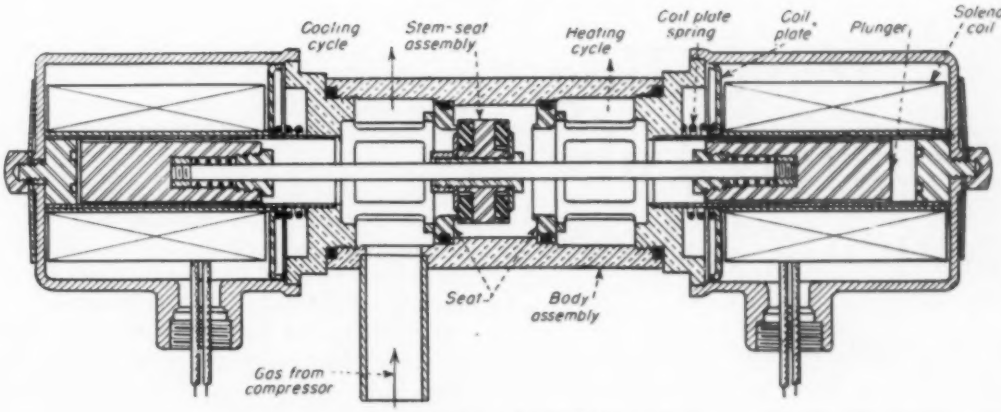
To heat. Closing of the heating contacts in the room thermostat energizes a series of relays completing a circuit through the unloading valve. When pressures have equalized, the circuit through the pressure difference switch is completed to the three-way solenoid valves, positioning them for the heating cycle. Continuation of the electrical circuit through the latching relay starts the compressor and both fans. When the discharge pressure rises about 25 psi above the suction pressure, the pressure difference switch removes power from the latching relay and the solenoid valves. But the relay is held in position by a mechanical latch and the gas pressure keeps the solenoid valves in position. As the room temperature reaches the thermostat setting, heating contacts open dropping out the heater relays and removing power from the compressor and fans.

To cool. The cooling contacts upon closing complete an electrical circuit to the solenoid valves positioning them for the cooling cycle. If the system had been operating on the heating cycle and the pressure difference switch is kept open by the difference between discharge and suction pressures, the unloading valve is energized equalizing the pressures and closing the pressure difference switch. This action changes the position of the latching relay which has been mechanically latched in the position determined by the previous energizing of the latching coil. Now the unloading valve is dropped out of the circuit and the 3-way valves are positioned for the cooling cycle starting the compressor and both fans.

To defrost. A defrost switch responding to a static pressure rise across the outdoor coil actuates a relay stopping the heating cycle and starting the cooling cycle with the outdoor fan stopped. When the frost is removed by the opening of a pressure switch, the defrost relay opens and electrical control over the pump's operation is returned to the room thermostat.



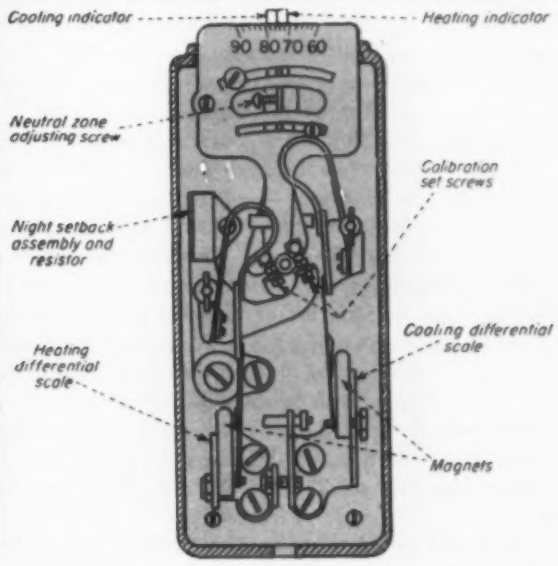
SUCTION SOLENOID VALVE

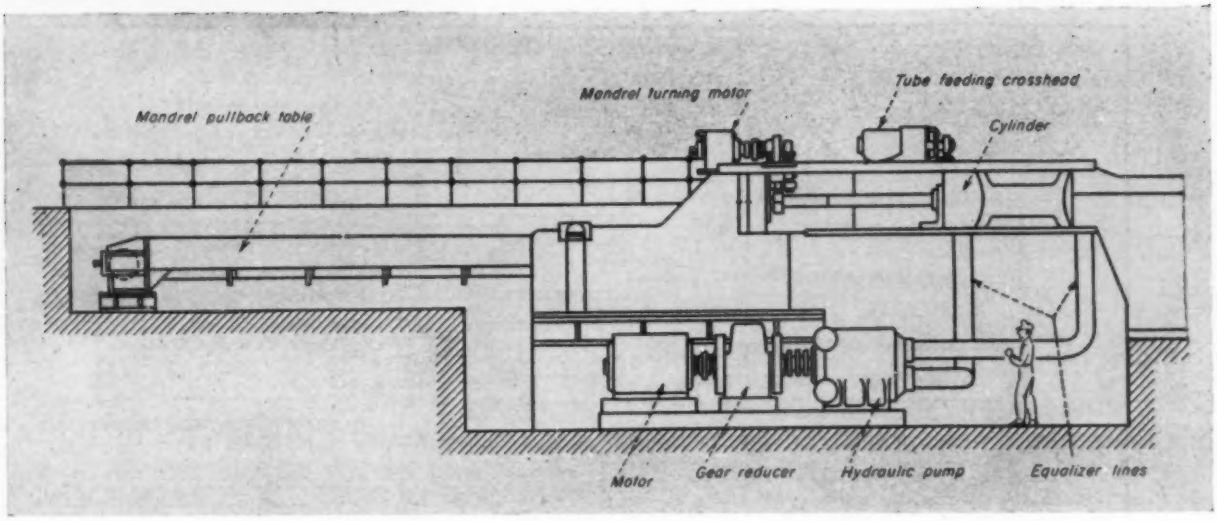


DISCHARGE SOLENOID VALVE

THE THREE-WAY valve solenoids, because of their large port diameter do not operate against a pressure difference of over 3 to 5 psi. Only when the pressure difference across the valves is low will the pressure difference switch allow the valves to change position. Thus, in every cycle change, an unloading valve equalizes the pressure before the pump can operate on a new cycle.

ROOM THERMOSTAT consists of two separate snap acting thermostats containing individual heating and cooling circuits. About 4 F is the minimum differential within which the heating or cooling contacts can be set for initiating the proper cycle.





Preloading Controls Tube Reducing Forces

From a 6½ in machine now used in production to building a new 18 in capacity compression reducing machine capable of turning out precision seamless tubing ranging in size from 17 to 9 in and in wall thicknesses down to 0.125 in, the Tube Reducing Corp. has incorporated into the design the feature of preloading the saddle frame, rolls and roll neck bearings to offset the calculated 3,500,000 lb separating force between the two rolls.

Being constructed by the E. W. Bliss Co. for the Wallington, N. J. firm, the new tube reducer will operate in a similar manner to the smaller unit—a roll housing or "saddle" reciprocating over a stationary tube drives two rolls in synchronization to "rock" over the tubing reducing the sectional area and elongating the tube.

Preloading consists of placing a compression force to maintain the position of the reducing rolls up to the maximum safe separating force. To preload the frame, the four tie rods holding together the frame to the housing are constructed with cal-rod units near the top center of the rods. By heating the tie rods and then tightening the securing nuts down on their expanded length, a high compressive load results when the rods shrink back to normal.

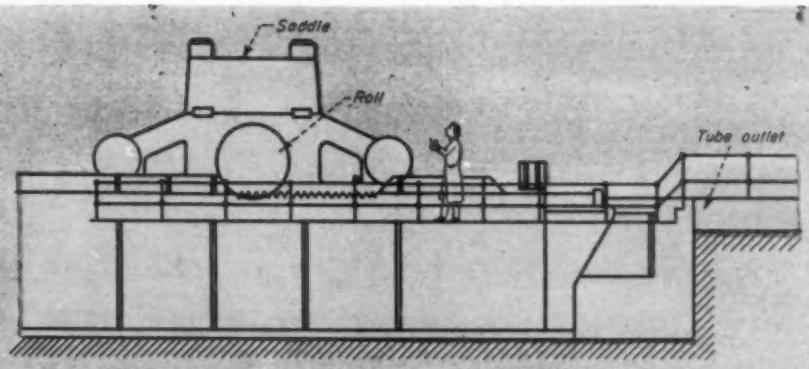
Hydraulic cylinders are used to vertically adjust the bottom roll. Since the two rolls run on each other, preloading the cylinders maintains the position of the bottom roll during the rocking operation.

To keep the reciprocating mass of the machine to a minimum and to insure the necessary flexibility for the rolls under the large separating forces, large taper i.d. spherical roller bearings are fitted on the roll necks during assembly. Hydraulically expanded and then allowed to return to their normal diameter on the shaft results in a radial preloading in the bearings.

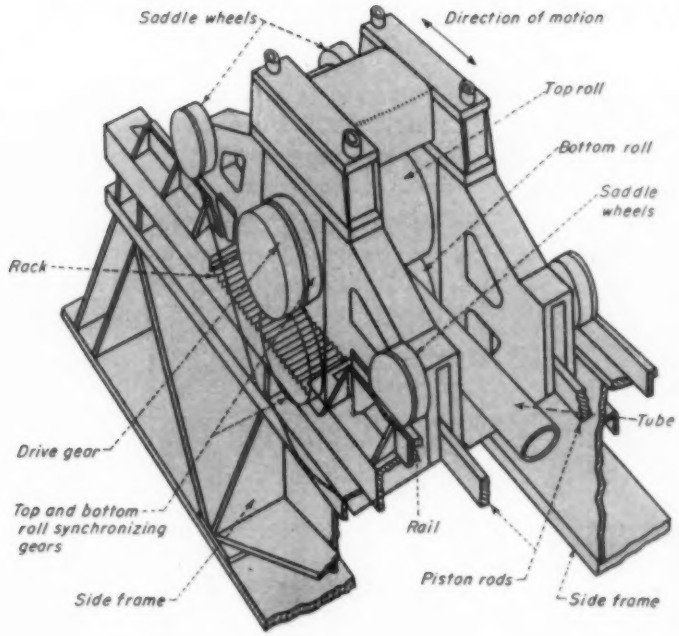
The rolls for the machine are 50 in dia, dictated by the size of the large bearings needed to support the rolling loads. Gears on each end of the top roll engage in stationary racks mounted on the machine frame and rotate the roll as the housing reciprocates. Toward the center from these gears are synchronizing gears which mesh with similar gears on the bottom roll to give a coordinated motion to both rolls. The weight of the saddle is spread through four wheels rolling on stationary tracks.

Specially designed variable displacement hydraulic pumps acting through a pair of cylinders furnish the drive. Reversal of flow and variation in cylinder pressure are controlled by varying the oil flow from the pump. Movement of the wobble plates is in turn controlled by an unique servo-mechanism which uses the phase shift between the saddle and pumps to give the controlling force.

The pumps are driven by 700 hp synchronous motors through a speed reducer. A flywheel on the high speed shaft of the reduction gear box allows the stored energy of the system to pass alternately from the saddle to the flywheel. Without this arrangement, up to a 7500 hp motor would be needed, the lost energy in the system being dissipated in heating the oil.



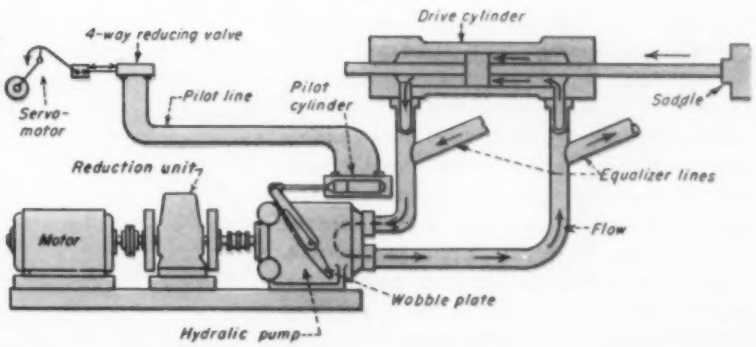
NEW tube reducing machine, over 100 ft long when fully constructed, will be used to produce thin-walled, high strength tubing for military aircraft applications. Four principal sections make up the machine—roll section housing at one end, tube feeding equipment in the center, the drive assembly, and the mandrel handling mechanism.



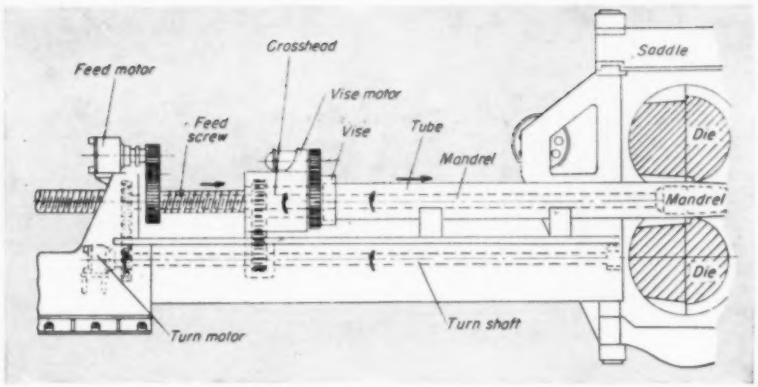
(BELOW) Schematic of the hydraulic drive circuit. The saddle is reciprocated by two cylinders each driven by a separate hydraulic pump. Movement of the two drive pistons is coordinated by equalizer lines. The pumps are controlled by servo-motors acting through pilot cylinders to regulate the reversal of flow and the variation of pressure in the drive cylinders. In the position shown, the wobble plate is allowing the maximum flow of oil into the cylinder moving it in the direction indicated. At the end of the piston stroke, the wobble plate is at the other extreme position reversing the oil flow and the direction of saddle travel. Inertia of the 150 ton saddle in motion pushes oil out of the decreasing end of the cylinder against the pump. The wobble plate moving toward the center position causes the pump to develop a back pressure which slows the saddle to a stop at the end of the stroke, the pump acting as the brake.

(continued on next page)

(ABOVE) Reciprocating motion of the wheel supported saddle—supplied by two piston rods connected to drive pistons—is changed to a rocking motion of the tube reducing rolls by two drive gears in mesh with stationary racks. Meshed top and bottom synchronizing gears insure uniform movement of the reducing rolls. To prevent damage that could result from accidental overfeeding, the hydraulic cylinders used to support the bottom roll have safety valves for quick dumping of the oil to relieve the load.



TO PREVENT free movement of the tube by action of the rolls, the tube is secured in a vise mounted on a crosshead. Free to move on ways approaching the rolls, the crosshead contains a hollow spindle through which the mandrel rod passes. Non-rotating feed screws driven by feed screw nuts, which can automatically adjust their position to equalize the loads, move the crosshead toward the rolls. Uniform turning of the vises, located at both ends of the mandrel spindle, and the mandrels is done by two separate hydraulic motors turning a hexagonal shaft which rotates the crosshead vise.



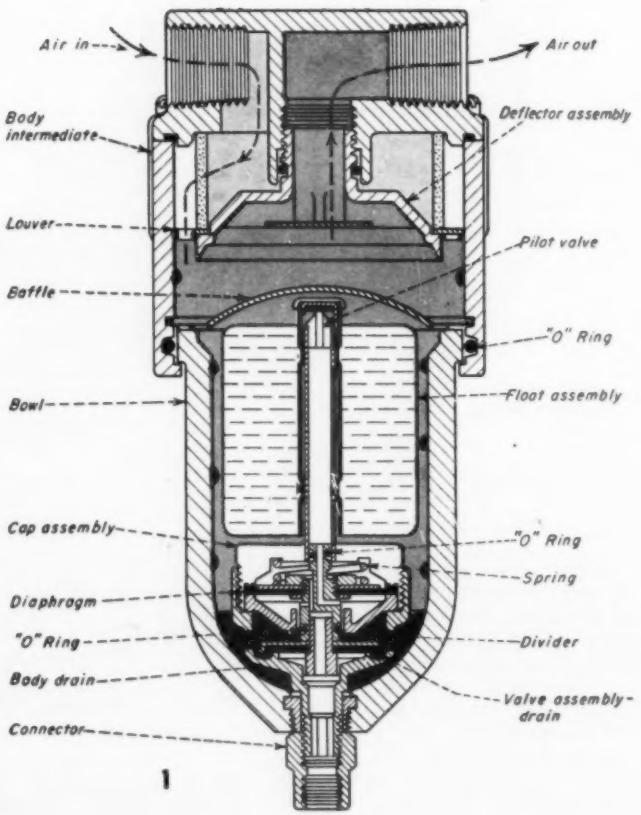
Pilot Valve in Float Automatically

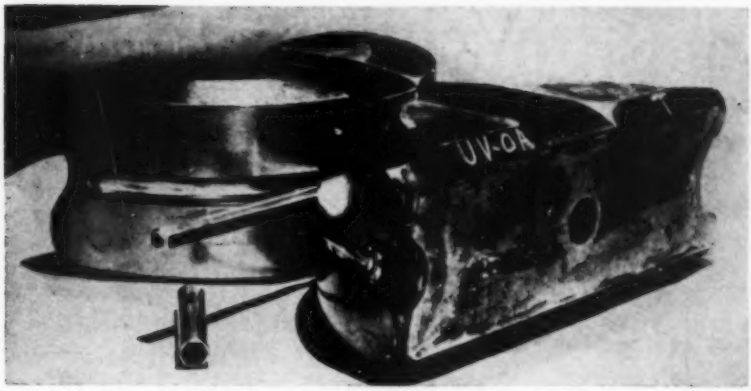
A new drain filter that automatically drains the condensate separated from the air in compressed air lines operates whenever there is pressure on the air system—whether the air pressure is constant or fluctuating, or whether there is or is not air flow through the system.

Designed by the C. A. Norgren Co., Englewood, Colorado, for application on air lines to portable and other air operated equipment where manual draining is impracticable, the drain filter does not rely on built-in restrictions or a pressure drop to make the drain function as found in conventional units.

Accumulation of the liquid in the bottom of the bowl raises the float mechanism opening a pilot valve to admit air into a chamber and under a diaphragm. Increased pressure under the diaphragm lifts the drain valve assembly allowing the liquid to drain. The fully automatic operation requires no adjustment, other than periodic inspection of the filtering elements.

Solids in the compressed air lines are filtered out of the unit before the air passes through the louvers into the moisture-removal chamber. The louvers are designed to impart a centrifugal action to the air, any moisture in the air falling into the chamber bowl. Air that is used to operate the drain valve assembly is made to pass through a baffle arrangement before entering the top section of the filter and out of the unit. This insures that air passing from the moisture-removal chamber to the outlet does not pick up any moisture removed in the lower section.





INSERTABLE DIES used with the rolls reduce tooling costs by making possible the changing of passes on the machine without completely changing the rolls. Each die will weigh approximately 7500 lbs, be 50 in. in diameter. Groove in die is tapered to allow free flow of extruded metal during reduction operation. Forces tending to push the die out of the roll are counteracted by a large rectangular key in the center of the roll and by ring segments arranged around the periphery wedged between the die and roll so as to resist the splitting forces on the groove.

Operates Filter Drain

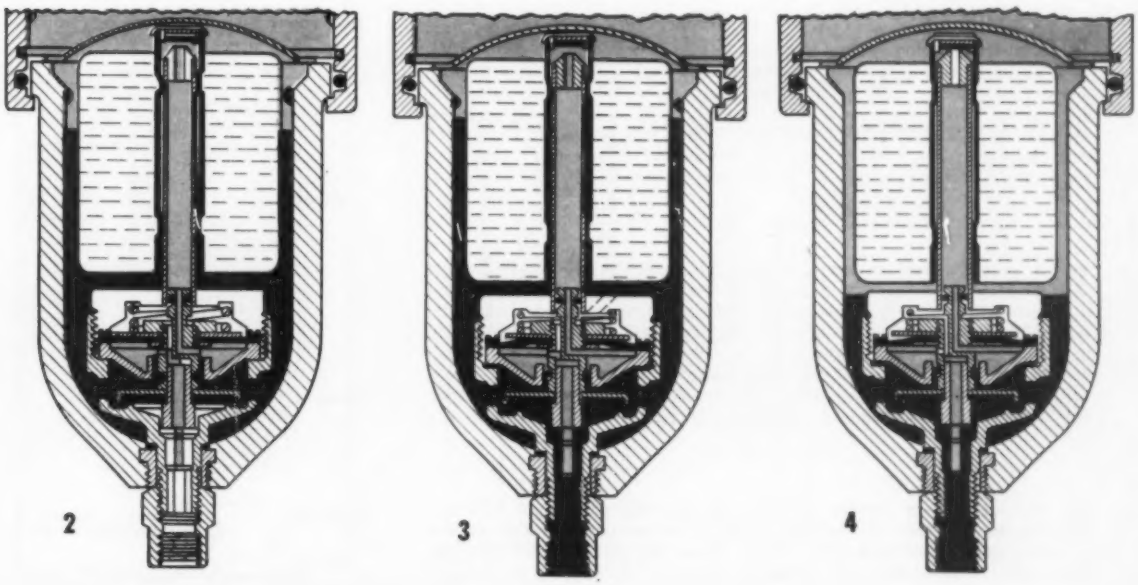
AIR LINE FILTER AND AUTOMATIC DRAIN
HOW THE DRAIN FILTER WORKS

1. After solids have been filtered from the air, the moisture is removed by a centrifugal action created when the air passes through louvers into the moisture-removal chamber. When liquid is first accumulating in the bowl, the drain valve and pilot valve are closed.

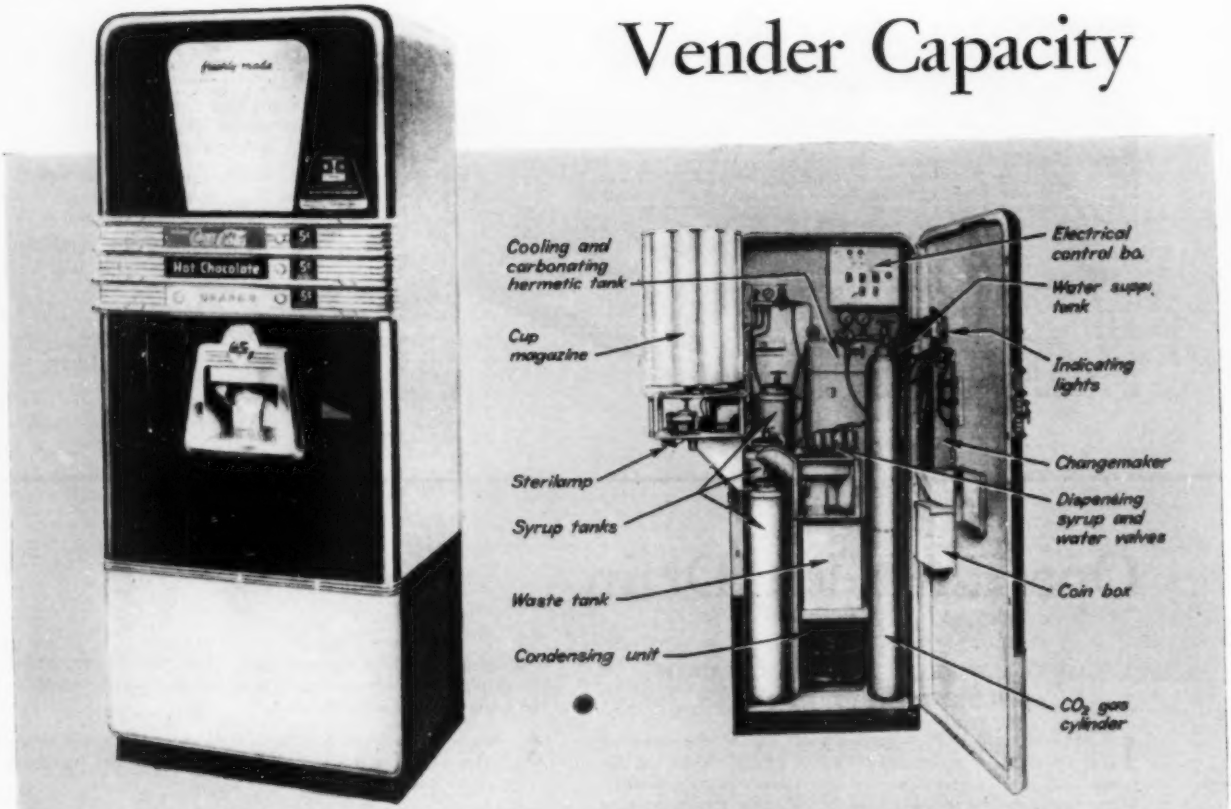
2. When the water level rises sufficiently, the buoyancy of the float opens the pilot valve admitting air into the stem. The air passes down the stem through a small port into a chamber and under a diaphragm. Since the pressure under the diaphragm is not enough to raise the drain valve assembly, the drain valve is still closed.

3. Air pressure has lifted the diaphragm raising the drain valve assembly from its seat and allowing the liquid to drain under pressure.

4. Draining of the water lowers the float to close the pilot valve. This action stops the entry of air into the stem and under the diaphragm. However, liquid will still drain until air bleeding from under the diaphragm lowers the pressure and allows the drain valve to seat.



Vender Capacity

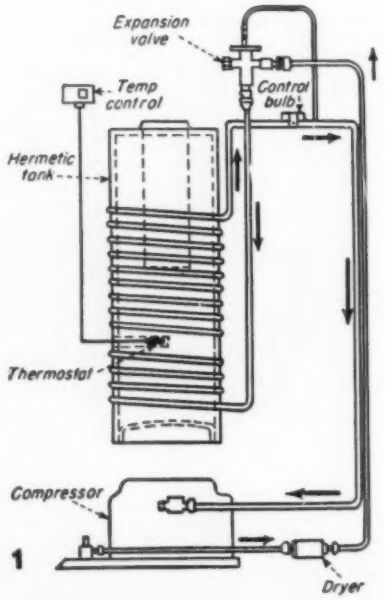


TO EFFECTIVELY use all available space within the 26 in by 24 in by 67 in cabinet, assembly clearances are small. Cup turret is hinged to swing out for easy servicing. Coin changer is only component mounted on door, permitting operation of the machine with door open.

1. The refrigeration system is usually set to maintain a 4F. differential. To insure that each drink is delivered at a 40 F temperature, a thermostat is mounted directly in front of the water intake valve. As soon as the water level falls enough to start the water pump, warmer water entering the tank spills over the thermostat and causes it to immediately actuate the refrigeration system. When the tank reaches 36 F, the thermostat then shuts-off the compressor.

2. A two electrode system maintains the proper water supply in the hermetic tank. As soon as the water level drops below both electrodes, a circuit to the pump is closed allowing the pump to operate and refill the tank. The water filling continues until the level reaches the short electrode at which time the water pump relay is closed and the pump is stopped. Should the level drop below the short electrode, the circuit is still closed through the long electrode. The water level must fall beneath the long electrode before the circuit is completed to the pump motor.

3. To improve the cooling efficiency of the machine and to enable a smaller and more effective tank design to be used, only a small amount of water and syrup is stored outside of the heavily insulated hermetic tank before dispensing. The syrup is precooled by passing it through several coils brazed to the top of the tank, permitting short lengths of tubing to the solenoid valves mounted directly over the dispenser.



Doubled Within Same Frame Size

By redesigning the cooling and carbonating tank for greater cooling efficiency, by rearranging the components within the cabinet and tieing the entire system together with a more compact and dependable electrical system, a new soft drink dispenser—Cole Products Corporation's Magniflo—was produced with double the 600 cup capacity of its identical sized predecessor.

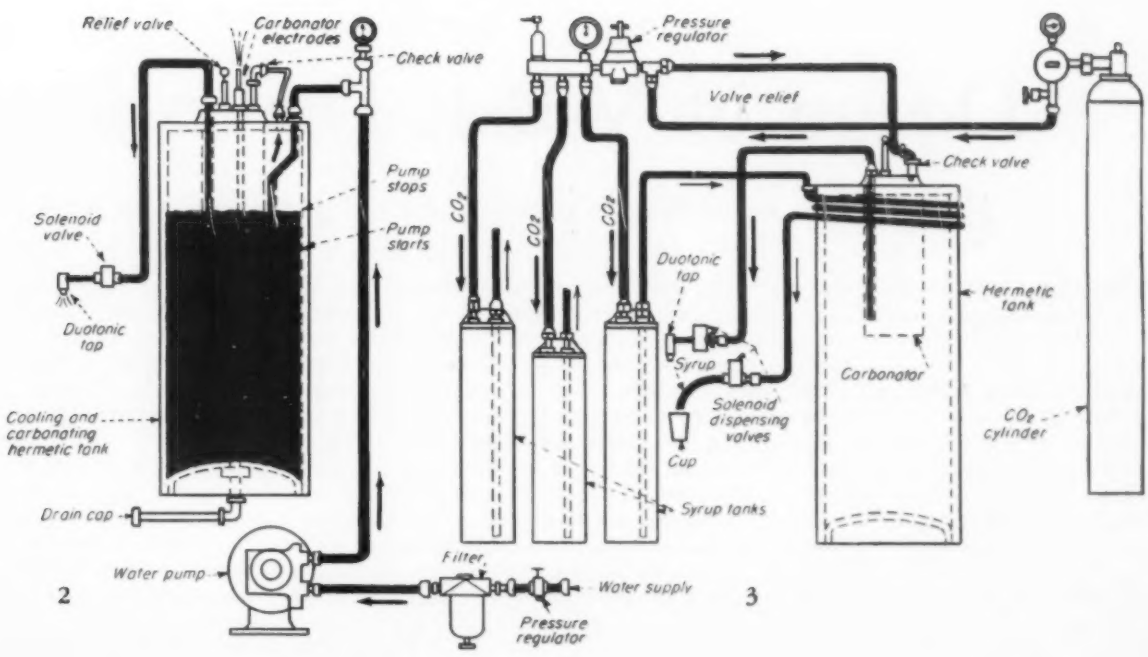
The new three flavor dispenser, capable of delivering one drink every 5 seconds cooled to 40 F or less, contains sufficient syrup capacity to dispense 2200 soft drinks in the ratio to their popularity.

To get the 1200 cup capacity within the same frame size as the 600 cup model, the number of stacks in the cup magazine was increased without altering the magazine height.

Doubling the cup capacity and improving the hermetic tank design went hand-in-hand since the increased capacity required a more efficient refrigeration system to prevent cooling losses, regardless of the rate of operation of the machine. Formerly, the tank cooled the water by means of copper refrigeration tubing brazed to the outside of the tank, and a thermostat responding to water temperature started and stopped the compressor within the thermostat differential. The new system has a thermostat located directly under the water intake valve in the tank so the warmer water pumped into the tank immediately starts the compressor.

Improvement in the cooling efficiency was also realized by precooling the syrup by passing it through coils brazed to the top of the hermetic tank. Syrup is now brought directly from the coils to the dispensing valves in the front of the machine resulting in only small amounts of water and syrup being outside the tank before dispensing.

The development of a new delivery tap solved the problem of the proper degree of carbonation for the delivered drink. Heretofore dispensing machines could not match the carbonation of bottled drinks without "beating" the drink and allowing excessive carbonation loss.



A PORTION of Gates Rubber Company's V-belt testing laboratory, considered the largest in the world, where Gates engineers established the fatigue-rate curves for V-belts, as given in this article. (Right) One of the hundreds of testing machines in the Gates V-belt laboratory that run day and night. Here a belt is undergoing a standard life test. More than 32,000 hr. of such testing is done every week in this laboratory.

Design of V-Belt Drives for

How to calculate the right belt size and sheave diameters to give

WILLIAM SPENCER WORLEY
Product Application Engineer
The Gates Rubber Company

THOUSANDS OF TESTS made in the laboratories of the Gates Rubber Company have definitely established that V-belts and the materials of which they are made have a fatigue life. Although the materials are amorphous, a plot of test results gives a curve similar to the S-N curve for metals of crystalline structure, except that a "knee" establishing the "endurance limit" has not been found in tests covering as high as 5×10^9 stress cycles. The Gates Rubber Company has used such curves in designing V-belt drives for more than ten years. In Fig. 1 is shown an *S-N* curve for V-belts as plotted from test data.

Structural elements subjected to cyclic loading are stressed to a pattern that simulates the loading cycle. In a gear the stress pattern is from zero to a peak stress during the tooth travel through the arc of contact. A rotating steel shaft is subjected in one cycle to a stress ranging from a peak tensile stress to an equal stress in compression. In a V-belt drive the stress variations over a cycle are not as simple.

In Fig. 2 is shown schematically a simple V-belt drive and below it the stress curve over the developed length of the belt. The curve shows the stress at any instant in a layer of the V-belt above the neutral axis at each

Table I—Service Factors for Light Machinery

Clothes Drier Tumblers	1.3
Compressors	
Reciprocating	1.5
Rotary	1.3
Fans and Blowers	
Centrifugal	1.0
Propeller	1.0
Generators	1.3
Ironers	1.0
Lawn Mowers	
On Nameplate Rating of Electric Motor	1.5
On Maximum Rating of Gasoline Engine	1.0
Machine Tools	1.4
Office Machines	1.2
Pumps	
Centrifugal	1.1
Gear	1.3
Reciprocating	1.5
Stoker Worms	
On Normal Power Requirement	1.3
On Shear-Pin Torque	0.8
Washing Machine Tumblers or Agitators	1.3
Woodworking Machines	1.5

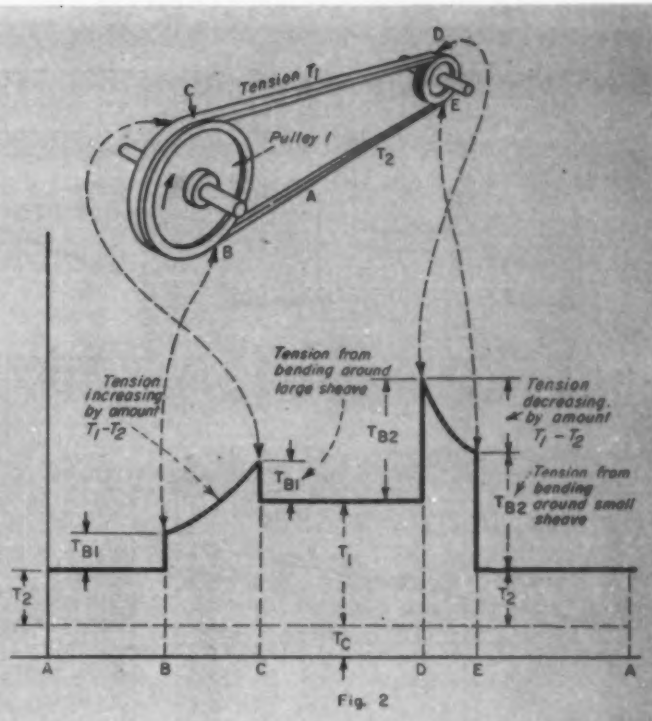


Fig. 2

Fig. 2—Schematic of a simple V-belt drive and the stress pattern over the developed length of the belt. The cumulative effect of the peak stresses determines belt life.

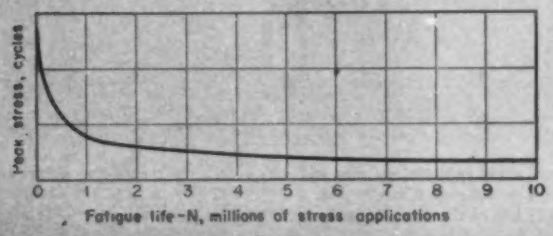


Fig. 1

Fig. 1—Typical fatigue life curve for V-belts as plotted from test data. It is similar to the fatigue life curve of steel.

Mass Produced Machines

satisfactory V-belt drives at the lowest first cost plus maintenance.

cross-section throughout the length of the belt. Therefore, the curve shows the variation in stresses or the stress cycle to which any piece or section of the belt is subjected as it travels through a complete revolution on the drive.

The belt stress curve in Fig. 2 shows two stress peaks, one at the point where the belt leaves the larger sheave, and the other at the point where the belt enters the smaller sheave. In one cycle of belt travel, every section of the belt is subjected to these stress peaks. The problem is to determine the fatigue life of the belt when subjected to cyclic stressing in which there are peak stresses of different magnitude during each cycle.

In attacking the problem of determining the fatigue life of the V-belt, we can apply the theory of cumulative fatigue. According to this theory, if the fatigue life of the belt at a cyclical peak stress S is N cycles, then X applications of that stress consume the fraction X/N of the life of the belt. If N were 10,000,000 and X were 5,000,000, then $\frac{1}{2}$ the life of the belt has been used or consumed. If Y applications of stress S' for which fatigue life is N' were now made, an added Y/N' fraction of the life of the belt would be consumed.

The theory of cumulative fatigue assumes that the successive fractions of fatigue life consumed at successively different stress magnitudes and numbers of application can be added

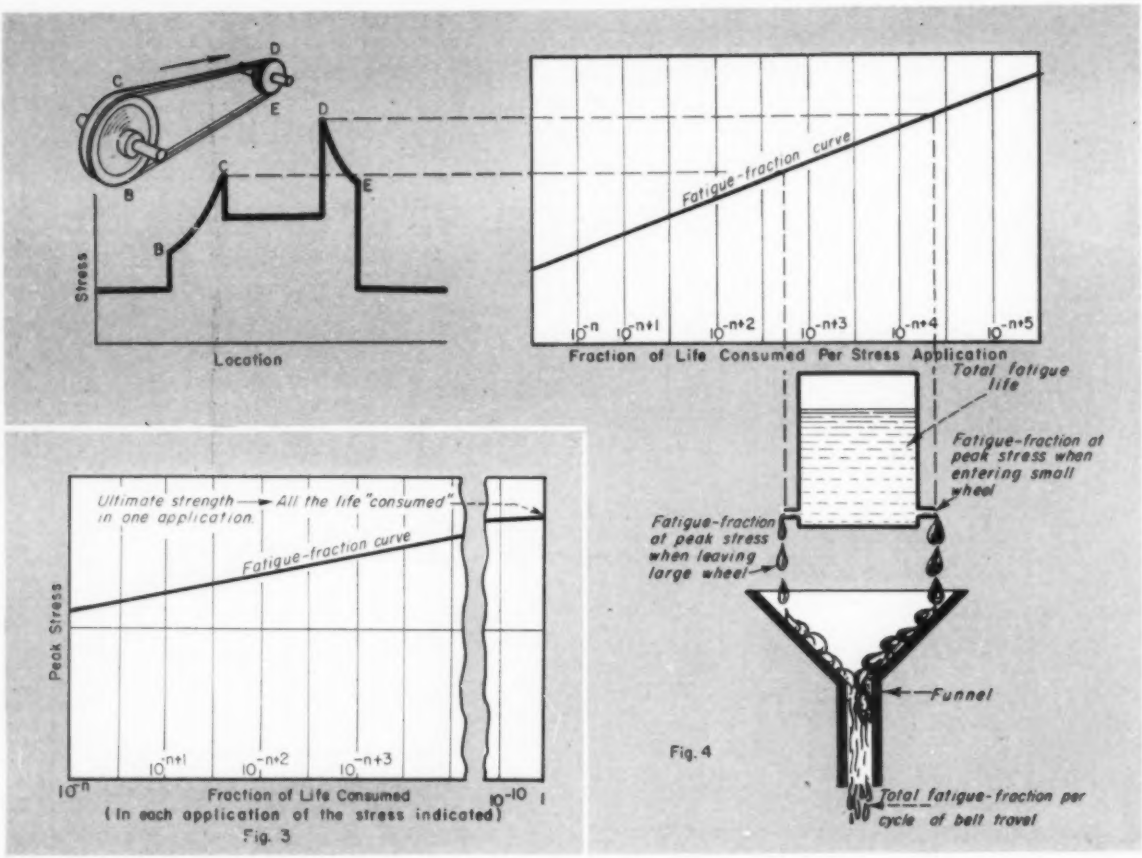


Fig. 3—Here the abscissas are the reciprocals of the number of given stress-applications that will cause failure. Hence the abscissas are the fraction of life consumed or used in one application of the corresponding stress. Fig. 4—Here is shown how the fatigue-fractions at different peak stress add and consume the total fatigue life of the belt. Reciprocal of total fatigue-fraction is belt life.

arithmetically. For example, assume that in the above-mentioned belt test Y were 3,000,000 applications of stress S', and N' were 9,000,000, the 3,000,000 applications of stress S' would consume $\frac{1}{3}$ the life of the belt. This added to the half already used would bring the total to 50 plus 33, or 83 per cent of the life of the belt has been consumed.

In going through the complete cycle of belt travel, any given piece or section of the belt will be subjected once to each stress speak. This greatly simplifies the problem because X will always equal Y. To solve a given problem, it is merely required to find from the S-N curve the fatigue life of the belt at each of the stress peaks. The reciprocal of each fatigue life will be the fraction of life taken out of the belt by one application of this peak stress. The corresponding fraction for each of the other peak stresses (one for each wheel on the drive) are determined in the same way. All fractions are added, the total being the fraction of life taken out of each cross-section of the belt in making one complete revolution around the drive. The reciprocal of this number will be the life of the belt in terms of number of revolutions of the belt on the drive.

In the above determination of the fatigue life of a V-belt, we use "the reciprocal of the sum of the fractions", the fractions being the fraction of the fatigue life taken out by one application of each of the peak stresses. This suggests that, instead of an S-N curve, we use a curve of S versus $1/N$. Fig. 3 shows the curve of Fig. 1, replotted with $1/N$ as the abscissa. It shows the fraction of life dissipated by one application of peak stress. It is called the "Fatigue-Fraction" curve.

In Fig. 4 is shown, pictorially, the relationship between peak stresses, the fatigue-fraction curve of the belt, and the life of the drive. The size of the drops of fluid falling out of the tank indicate the fraction of fatigue life consumed per cycle of stress in the V-belt. The two drops join to indicate the total fatigue life used in one belt revolution. This illustrates the theory of the summation method for determining the life of a V-belt drive.

The above theory cannot be proved mathematically. However, at the Gates Rubber Company in the past thirteen years we have made thousands of tests on numerous types of belts. These tests are supported by the performance and life of hundreds of V-belt applications that have been checked and followed closely by Gates' engineers. Tests and application results both confirm the theory.

The general formula for the stress-fatigue relationship is:

$$\log N = A - BP \qquad (1)$$

Where:

N = Average number of stress cycles to belt failure
$= Vhn/L$
P = Peak stress in cycle

Expressed in terms of the variables of the drive, the formula becomes:

$$\log \frac{720\ Vhn}{L} = A - B\,(T_1 + T_b + T_c) \quad (2)$$

$$T_1 = \frac{R}{R-1}\,\frac{33000\ HP}{V}$$

$$T_b = \frac{2fE_1A_1(k_1 - k)\,t}{d} + \frac{mV^2}{3600}$$

$$T_c = \frac{mV^2}{3600}$$

Where:

V = belt speed, feet/minute
h = average belt life, hours
n = number of wheels
L = belt length, inches
A, B = experimentally determined slope and intercept of the fatigue curve
R = $e^{0.52\theta}$, the tension ratio T_1/T_2, for an arc of contact θ, radians
HP = horsepower load
f = experimentally determined bending stress modification factor
E_1 = tensile section modulus, pounds/square inch
A_1 = tensile section area, square inches
k_1t = distance from bottom of belt to tensile centroid, inches
kt = distance from bottom of belt to weighted centroid of all belt components, inches
d = pitch diameter of sheave, inches
m = mass of belt, slugs/foot
T_1 = tight side tension
T_b = bending tension
T_c = centrifugal tension

Remembering that $\log (1/N) = -\log N$, we can write the equation in fatigue fraction form thus:

$$\log (L/720\ Vhn) = B\,(T_1 + T_b + T_c) - A \quad (3)$$

As outlined above, the fatigue-fraction is evaluated at each wheel. Therefore in the above formula n is set equal to one, since the belt passes each wheel but once in a revolution. Adding the fatigue-fractions automatically takes care of "n" in the total fatigue-fraction.

The belt speed, V, appears on each side of the above formula, and is the only variable which does so. To get a quantity which does not have the belt speed as a factor, we have found it convenient to rewrite Equation (3) in the following form:

$$\log \frac{L}{h/100} = B\,(T_1 + T_b + T_c) - A + \log 72{,}000\,V \quad (4)$$

The quantity on the left-hand side is still related to the fatigue-fraction, but now has the dimensions of a velocity, length/time. It is called the "Fatigue Rate", and represents the length of a belt which would be completely fatigued in 100 hours. The fatigue rates for the various wheels can be added, just as the fatigue fractions can. Dividing the belt length by the total fatigue rate gives the average belt life in hundreds of hours.

Designing Two-Wheel Drives

With the rpm of driveR and driveN sheaves established by the problem, the first step is to choose the pitch diameter of each of the sheaves. Obstructions and space restrictions might limit the diameter of one of the sheaves. If so, start by determining the maximum usable pitch diameter of that sheave. The pitch diameter of the other sheave is then calculated from the required ratio of rpm of driveR and driveN shaft.

The above calculations determine the pitch diameters. These should be checked immediately against the space available, keeping in mind that the outside sheave diameters may be as much as 0.30 in. greater in diameter, and that as much as $\frac{7}{16}$ in. on radius may be required to put the belt into the sheave. It might be necessary to repeat the pitch diameter calculations to get the sheaves to fit in the space.

Step number two is to determine the minimum center distance between the shafts. Usually one or both shaft locations are fixed by the problem. If there is a choice in the positioning of one of the shafts, the center distance should be about $(D + 3d)/2$ or D, whichever is the larger, D and d being the diameter of the large and small sheave, respectively.

Horsepower to be transmitted by the belt can be estimated from the rating on the nameplate of the engine or motor if all the power developed by the engine or motor is being delivered through the belt. If the power cannot be determined in this manner, as in a drive between two jack shafts or spindles, it should be determined by test or calculations.

Judgment must be used in determining from the nameplate the power delivered by the motor or engine. Under the old standards, the electric motors were good for a continuous output at 50 per cent overload above nameplate ratings. The new NEMA ratings which may soon go into effect do not permit appreciable continuous overload.

Table I gives "service factors" by which the estimated power transmitted is to be multiplied in order to allow for shock and momentary overloads.

With all of the data required for the solution of the problem, the next phase of the design is "checking out"

Table II—Acceptable Belt Life for Various Machines

Type of Machine	Acceptable Belt Life Range
Domestic Machines:	
Hobby or Intermittent Service. (Home work shop tools, sewing machines, lawn mowers, motion picture projectors, etc.)	5–10
Periodic or Seasonal Service. (Clothes washers, driers, ironers, furnace blowers, seasonal air conditioners, etc.)	15–20
Continual Service. (Refrigerator, year-around air conditioning, water and light systems, etc.)	50–100
Industrial and Commercial Machines:	
Intermittent or Seasonal Service. (Service station compressors, gasoline pumps, meat slicers, job shop tools, etc.)	30–50
Continual Service. (Small machine tools, office machines, light-process machinery, etc.)	75–200

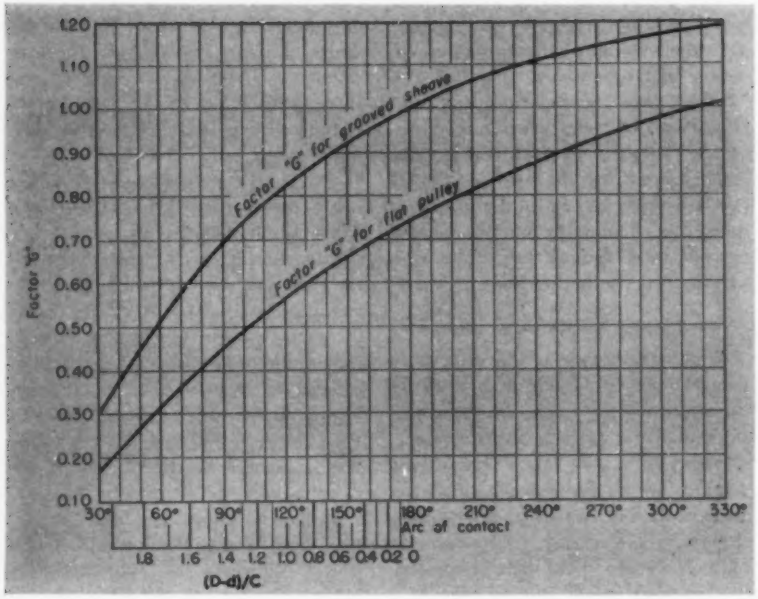


Fig. 5—Subtract 15 deg. from the arc of contact corresponding to the calculated value of (D-d)/C. The corresponding G factor is divided into design horsepower to give effective wheel horsepower.

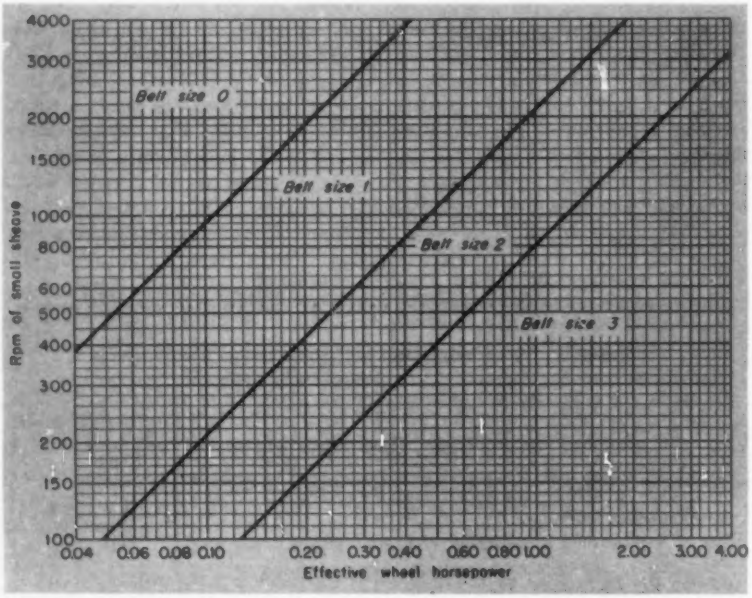


Fig. 6—The coordinate point of effective wheel hp and rpm of small sheave indicates belt cross section size to use. If point is close to a diagonal, investigate both sizes.

the drive to determine the belt life that will be obtained.

The formula for required belt length is as follows:

$$L = 2C + 1.57\,(D + d) + \frac{(D - d)^2}{4C} \qquad (5)$$

All the units are inches. L is the length at the pitch line, C is center distance, and D and d are the pitch diameters.

Belt speed V in feet per minute will be:

$$V = \frac{\text{rpm times pitch diameter}}{3.82} \qquad (6)$$

Use either D or d and the corresponding rpm.

Next decide upon the lowest average belt life which can be considered satisfactory for the drive. Table II shows the average belt life, in hundreds of hours, that has been found satisfactory for many types of machines. In using this table to arrive at an "Acceptable Belt Life", the following factors must be considered:

(a) The hours the drive will operate per day, week, month, or year.

(b) The period of time desired between belt replacements.

(c) The probability of longer or more severe usage than normal in some applications or some geographical areas.

(d) The warranty period to be placed on the machine.

(e) The degree of uncertainty about the magnitude and character of the loads the drive will carry.

(f) The possibility of heavier drive loads if and when optional or auxiliary equipment is added to the machine.

This last is of special importance, and is often overlooked.

Effective Wheel Horsepower

The horsepower load calculated, estimated, or determined by test, as stated above, is next multiplied by the service factor. This gives the design horsepower.

If the driveR and driveN sheaves are the same diameter, the design horsepower could be used in the nomograms since they are based on a tension ratio, R, of 5 corresponding to an arc of contact of 180 deg. For the usual drive, where the arc of contact for the small sheave is less than 180 deg., the tension ratio will be less than 5 and it will require greater belt tension, T_1 and T_2, to transmit a given horsepower. The design horsepower, in such a case, does not give a true picture of the tight-side tension required. It is necessary to apply to it a correction Factor "G", which depends on tension ratio and arc of contact. The result is the effective wheel horsepower.

In multiple-wheel drives, the determination of effective wheel horsepower must also consider the fact that a belt strand which is the tight side for one wheel might be the slack side for the next wheel. But for the present we will concern ourselves only with two-wheel drives.

In Fig. 5 are shown curves for the

quick determination of the arc correction Factor "G". The first step is to calculate or measure the arc of belt contact on the smaller wheel. To simplify its calculation, we merely figure $(D—d)/C$, and from the scale at bottom of the chart immediately get the corresponding arc of contact from which we subtract 15 deg. The subtraction of 15 deg. is to correct for the effect of centrifugal force and belt stiffness in diminishing the theoretical arc of contact. For the corrected arc of contact, pick off the curve the correction Factor *"G"*. The design horsepower is then divided by *"G"* to obtain the effective wheel horsepower.

Selecting the "Best" Size of V-Belt

A belt of the "best" cross-section will give longer life on a given drive than a belt of any other cross-section. A belt smaller than the "best" cross-section will be over-stressed by the tension required to transmit the power. A belt larger than the "best" cross-section will be over-stressed in bending around the sheave because of its greater stiffness.

The curves in Fig. 6 were obtained by solving the fatigue rate Equation (4) for the conditions under which two adjacent belt cross-sections would give equal fatigue rates for the same rpm, diameter, and horsepower. With the effective wheel horsepower and the rpm of the small sheave known, the intersection of the ordinate and abscissa indicates the belt size to use. If the point of intersection falls close to one of the heavy diagonal lines separating two fields of sizes, both belt cross-sections should be investigated. Usually it will be permissible to use the smaller size, which will be the more economical one.

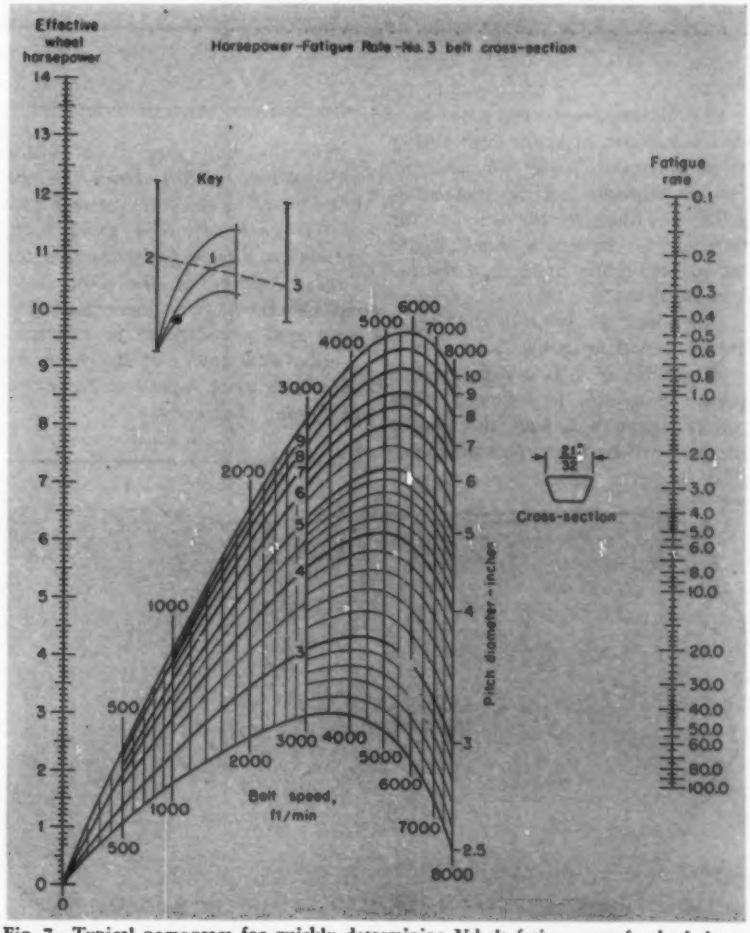


Fig. 7—Typical nomogram for quickly determining V-belt fatigue rate for both large and small sheave, the sum being total fatigue rate, which divided into belt length in inches gives belt life in hundreds of hours.

Fatigue Rate and Calculated Belt Life

The nomogram in Fig. 7 was calculated from the fatigue rate Formula (4). It gives the fatigue rate of the given V-belt when transmitting the calculated effective wheel horsepower at the specified belt speed and pitch diameter of the sheave. Similar nomograms covering other belt cross-sections are given on the gate-fold "Design of Two-Wheel V-Belt Drives," elsewhere in this issue.

To use the fatigue-rate charts, locate the point where the ordinate of belt speed crosses the curve of the pitch diameter of the sheave, either driveR or driveN. A straight line connecting this point with the calculated effective wheel horsepower, and extended to the fatigue-rate scale, gives that quantity. Find the fatigue-rate, using the pitch diameter of each sheave in turn. Add the two fatigue-rates obtained. This will be the total fatigue rate. Divide this quantity into the belt length in inches. The result is the calculated belt life in hundreds of hours.

Assuming that the horsepower load is correct, and that the service factor accurately reflects the effect of peak loads and load fluctuations on the drive, the average belt life will be reasonably close to the calculated belt lift. If load and service factor have been overestimated, average belt life will be greater than calculated. Similarly, if load and service factor have been underestimated, average belt life will be less than calculated.

Weighing and Revising

The accompanying Table III shows how to judge whether or not the belt life as calculated will be satisfactory. If the results of the study made as indicated by Table III show that the drive is "over" or "under" designed, the first step in the reanalysis is to investigate redesigns using different pitch diameters for the sheaves or wheels. The effective wheel horsepower as already figured can be used in the reanalysis. Assuming the drive to be underdesigned, proceed as follows:

(1) Multiply the fatigue rate at the small sheave by the ratio of the calculated belt life of the drive, as

Table III—Judging the Drive

If the Calculated Belt Life is	And the Belt Cross-Section is:		
	"Best" Cross-Section	Smaller than "Best" Cross-Section	Larger than "Best" Cross-Section
Less than the Acceptable Belt Life	Drive is not good enough. Redesign the drive with larger wheels.	Drive is not good enough. Find Calculated Belt Life for "Best" Cross-Section.	Drive is not good enough. Find Calculated Belt Life for "Best" Cross-Section
Between 1 and 1⅓ times the Acceptable Belt Life	Drive is satisfactory. Go ahead with job: Check sheave grooves, take-up, etc.	Drive is satisfactory. Go ahead with job: Check sheave grooves, take-up, etc.	Drive can use a smaller belt and still be satisfactory; Find Calculated Belt Life for "Best" Cross-Section.
More than 1⅓ times the Acceptable Belt Life	Drive is better than it needs to be. 1. Find Calculated Belt Life for smaller cross-sections. 2. Redesign with smaller wheels.	Drive is better than it needs to be. Find Calculated Belt Life for next smaller cross-section.	Drive is better than it needs to be. 1. Find Calculated Belt Life for belts with smaller than "Best" Cross-Section. 2. Use "Best" cross-section and redesign with smaller wheels.

already determined, to the acceptable belt life. This gives the small sheave fatigue rate that will give a new calculated belt life approximately equal to the acceptable belt life.

(2) On the "Horsepower-Fatigue Rate" nomogram for the belt cross-section you are using, draw a light line from the effective wheel horsepower to the revised small sheave fatigue rate you just calculated. From the original small sheave pitch diameter and its rpm, calculate the belt speed and locate the pitch diameter-belt speed point on the chart. See Fig. 8. With this as the starting point, plot a few more pitch diameter-belt speed points, using increased pitch diameters and the same rpm each time. Where this plotted curve intersects the line drawn from the effective horsepower to the fatigue rate is the indicated new size of small sheave to use.

The curve of constant rpm-pitch diameter-belt speed can be plotted quickly with the help of a slide rule. Simply set the slide to indicate ratio of original pitch diameter to its corresponding belt speed in feet per minute. This ratio will be constant for all pitch diameters. Select the pitch diameters off of the one scale and read the belt speed on the scale that is immediately below it.

(3) Having found the new small sheave diameter, make the large sheave diameter greater in the same proportion as originally. Then proceed as before and calculate the belt life for the revised diameter. It should figure out to be slightly more than the acceptable belt life.

(4) Check to be sure the larger diameters will fit in the space.

When the drive is overdesigned, a similar procedure is followed. The correct design will have the longest life and will be the most economical.

Opposite this page is a folded "Two-Wheel V-Belt Drive Design Worksheet." Top center on each face of this worksheet, with tinted background, is a form for calculating the drives. Starting in the upper left-hand corner is given the explanation, data, and procedure to be followed.

Additional copies of this form are obtainable upon request to the editor of Product Engineering.

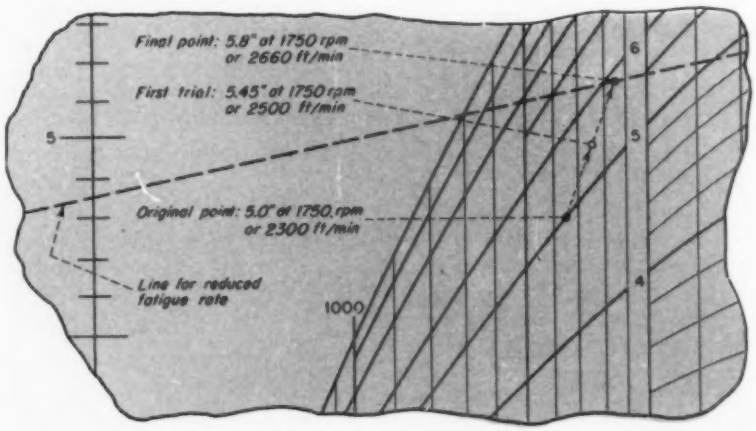


Fig. 8—Indicated procedure for using the chart, such as in Fig. 7, for determining the new small sheave diameter that will correct the drive if it has been under designed.

Two-Wheel V-BELT DRIVE Design Worksheet

BY
SPENCER WORLEY
APPLICATION ENGINEER
GATES RUBBER COMPANY

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TWO-WHEEL V-BELT DRIVE DESIGN

REFERENCE ITEMS

1 HORSEPOWER LOAD – Should be taken from test results when they are available. Otherwise, if all the power is to be transmitted through the belt, take as the load the nameplate rating of the electric motor or engine, or calculate it from the torque rating of hydraulic motor or air motor operating at maximum pressure.

2 Service Factors for Light Machinery

Clothes Drier Tumblers	1.3	Machine Tools	1.4
Compressors – Reciprocating	1.5	Office Machines	1.2
Rotary	1.3	Pumps – Centrifugal	1.1
Fans and Blowers – Centrifugal	1.0	Gear	1.3
Propeller	1.0	Reciprocating	1.5
Generators	1.3	Stoker Worms–On Normal Power Requirement	1.3
Ironers	1.0	On Shear-Pin Torque	0.8
Lawn Mowers –		Washing Machine Tumblers or Agitators	1.3
On Nameplate Rating of Elec. Motor	1.5	Woodworking Machines	1.5
On Maximum Rating of Gasoline Eng.	1.0		

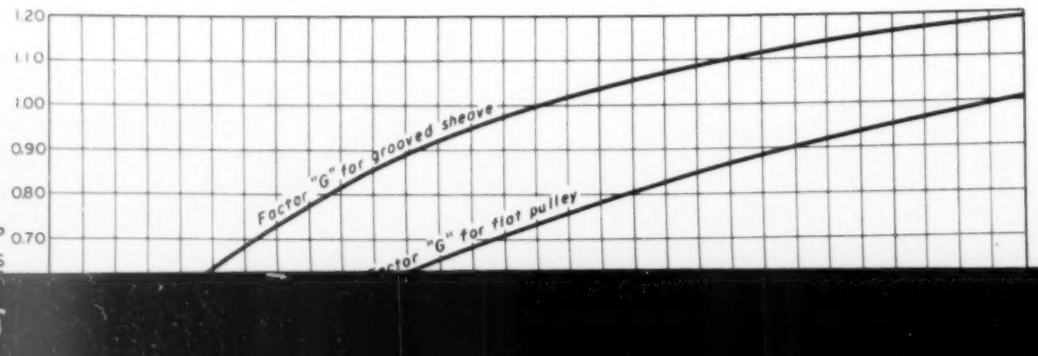
3 Acceptable Belt Life

Type of Machine	Acceptable Belt Life Range
Domestic Machines:	
Hobby or Intermittent Service. (Home work shop tools, sewing machines, lawn mowers, motion picture projectors, etc.)	5-10
Periodic or Seasonal Service. (Clothes washers, driers, ironers, furnace blowers, seasonal air conditioners, etc.)	15-20
Continual Sevice. (Refrigerator, year-round air conditioning, water and light systems, etc.)	50-100
Industrial and Commercial Machines:	
Intermittent or Seasonal Service. (Service station compressors, gasoline pumps, meat slicers, job shop tools, etc.)	30-50
Continual Service. (Small machine tools, office machines, light-process machinery, etc.)	75-200

To determine acceptable belt life, the following factors must be considered: hours of operation between belt replacements; above-normal usage; warranty period placed on machine; uncertainty about loads to be carried; possibility of heavier loads when auxiliaries are added to machine.

4 Arc of Contact and Factor "G"

Obtain (D-d) / C from Item 1 under "Setting Up the Problem."



(Numbers in Circles r

Company_____ Machine_

Address_____ Model No.

Part No._____ B. P. No._

SETTING UP

D = Pitch diameter, large wheel d = Pit
C min = (D+3d)/2 or D, whichever is larger

1: Fill in the following:

D=_____ D+

d=_____

D–d=_____ (D–d)/

Belt Length L=

2: Preliminary Information and Calculations:

Wheel	R.P.M.	Diameters	
		Pitch	Outside
DriveN			
DriveR			

CHECKING

1: Belt Length_____inches **2:** Be

3: Acceptable Belt Life **3** _____(hundreds

4: Horsepower and Fatigue Rate: "Be

Wheel	4 Arc of Contact	4 Factor "G"	5 Desig HP
DriveN			
DriveR			

5: Calculated Belt Life = Belt Length / Total Fatigue Ra

GN WORKSHEET

(Circles refer to Reference Items)

achine_____ Date_____

odel No._____ Designed by_____

P. No._____ Checked by_____

G UP THE PROBLEM

d = Pitch diameter, small wheel C = Center distance
s larger (unless determined by other considerations.)

D+d=_____ 1.57 (D+d)=_____

C=_____ 2C=_____

(D−d)/C=_____ (D−d)²/4C=_____

ength L=1.57 (D+d)+2C+(D−d)²/4C=_____

ations:

ers Outside	① Horsepower Load	② Service Factor

Note: Add 1" to D and d to obtain approximate outside diams. and check to find out if the sheaves will fit in space available. If fit is close, check again after belt size has been determined and exact O.D. can be calculated.

ING OUT THE DRIVE

2: Belt Speed_____feet/minute

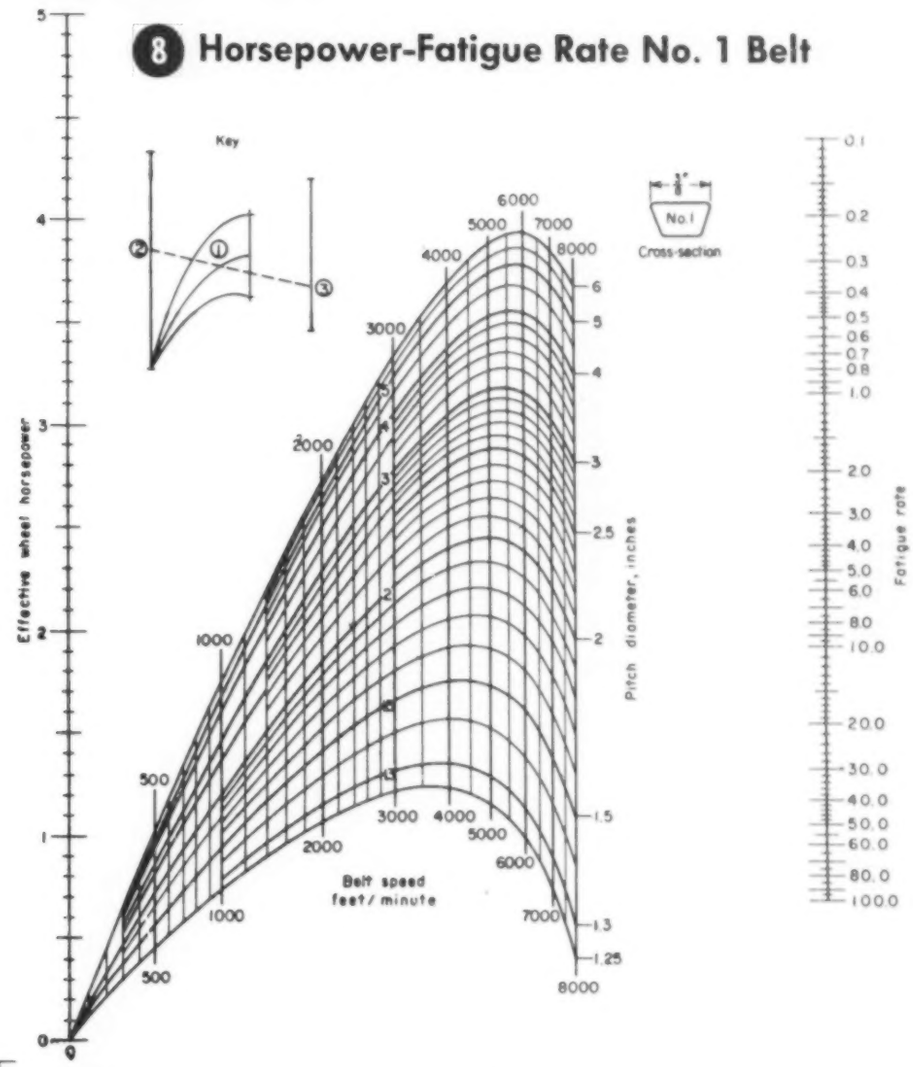
ndreds of hours)

"Best" Cross-Section ⑥_____ (⑦ ⑧ ⑨ or ⑩)

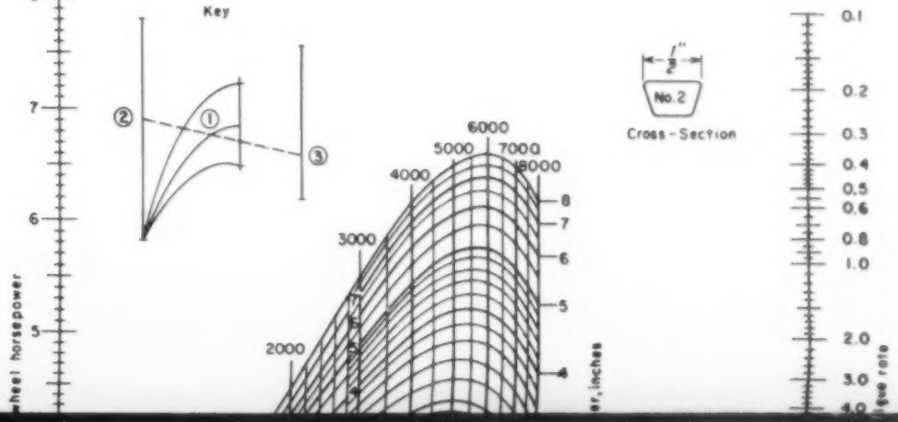
⑤ Design HP	⑤ Effective Wheel HP	Pitch Diam.	Fatigue Rate
		Total Fatigue Rate	

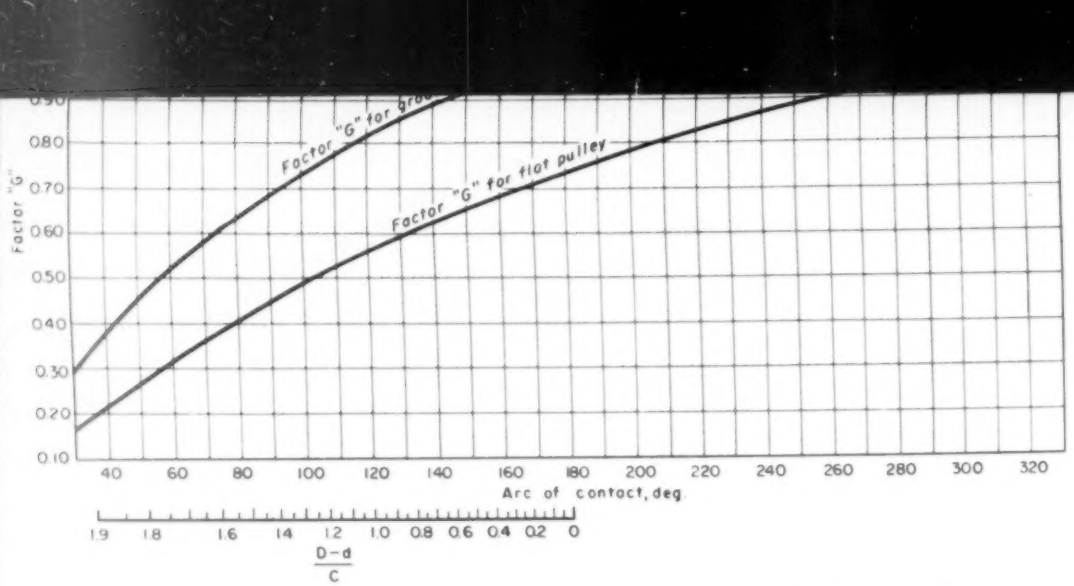
ength / gue Rate = _____ (hundreds of hours)

⑧ Horsepower-Fatigue Rate No. 1 Belt



⑨ Horsepower-Fatigue Rate No. 2 Belt





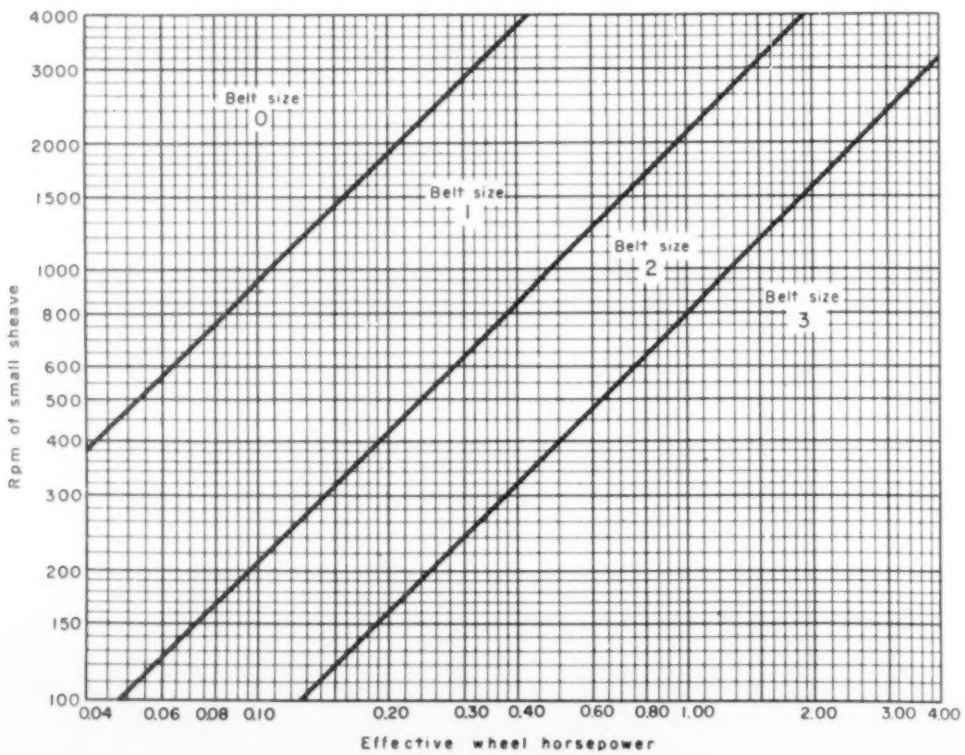
NOTE: Subtract 15 deg. from arc of contact as measured on layout or obtained from above scale. Use the result to find Factor "G". Obtain "G" for small sheave only. If (D-d)/C equal 0.5 or more, you may want to consider using a flat pulley. (See reference note (16) for instructions.)

5 Design HP=HP Load x Service Factor (2)
Effective Wheel HP=Design HP/Factor "G" (4)

(Effective wheel horsepower will be the same for the large sheave as it is for the small sheave.)

6 "Best" Belt Cross-Section

The intersection of a vertical line from the effective wheel horsepower with a horizontal line from the rpm of the small sheave indicates the cross-section which will give the longest service. If the intersection is on one of the heavy diagonals, choose the smaller cross-section.



5: Calculated Belt Life = Belt Length / Total Fatigue Rate =

HORSEPOWER-FA

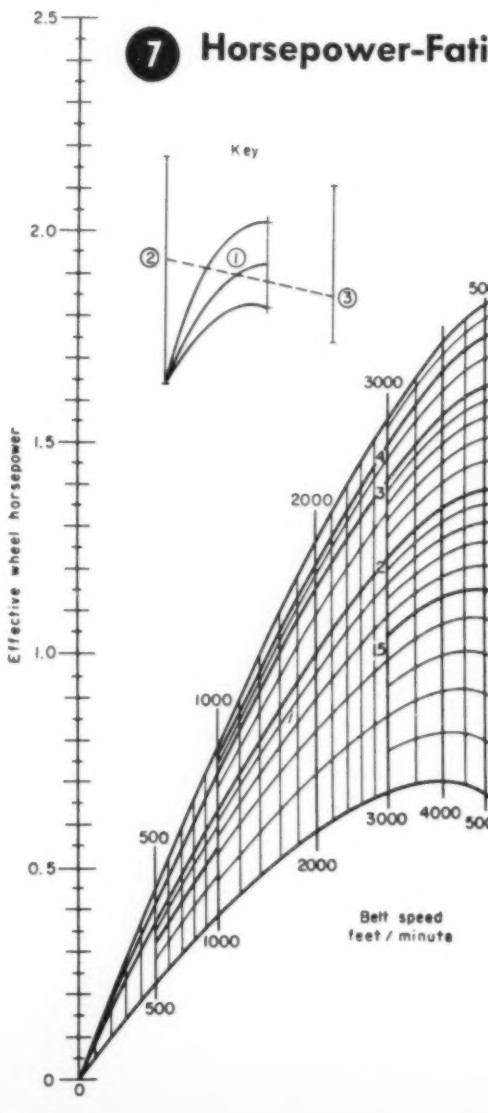
On a two-wheel drive every section of the V-belt is subjected to a peak stress when it leaves the driveN sheave, and again when it enters the driveR sheave. (See "Design of V-Belt Drives for Mass Produced Machines" by Spencer Worley, Product Engineering, September, 1953.)

Each peak stress application consumes a fractional part of the total fatigue life of the belt equal to the reciprocal of N on the S-N curve at the given stress.

For a given belt cross-section, the peak stress is a function of tight-side tension, pitch diameter of the sheave, and belt speed.

The value of T_1 is a function of belt speed, horsepower transmitted, service factor, and arc of contact. The last

7 Horsepower-Fati



Rate = ——— (hundreds of hours)

OWER-FATIGUE RATE

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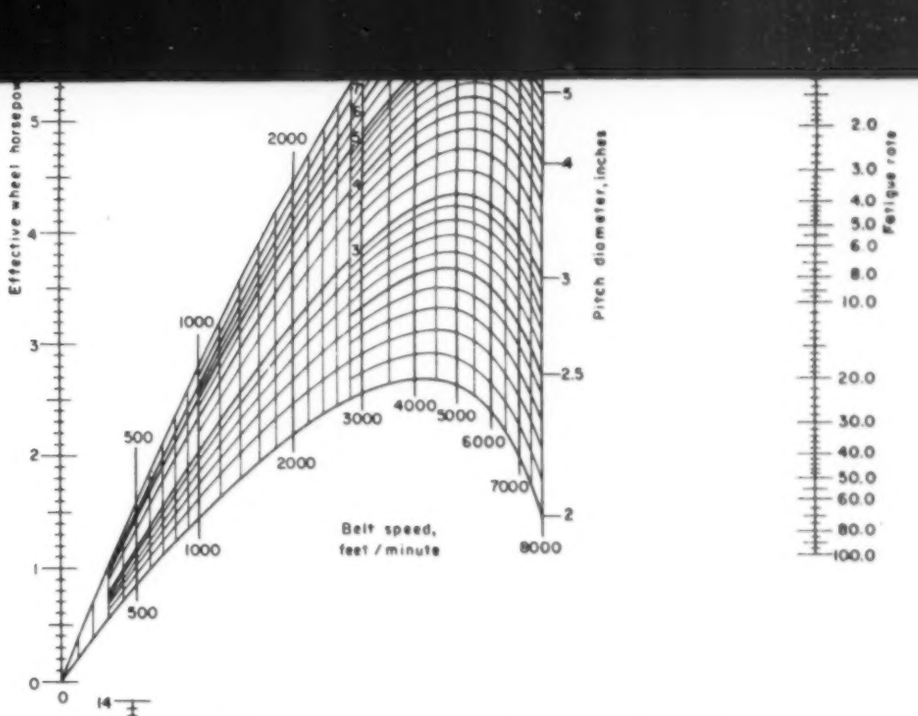
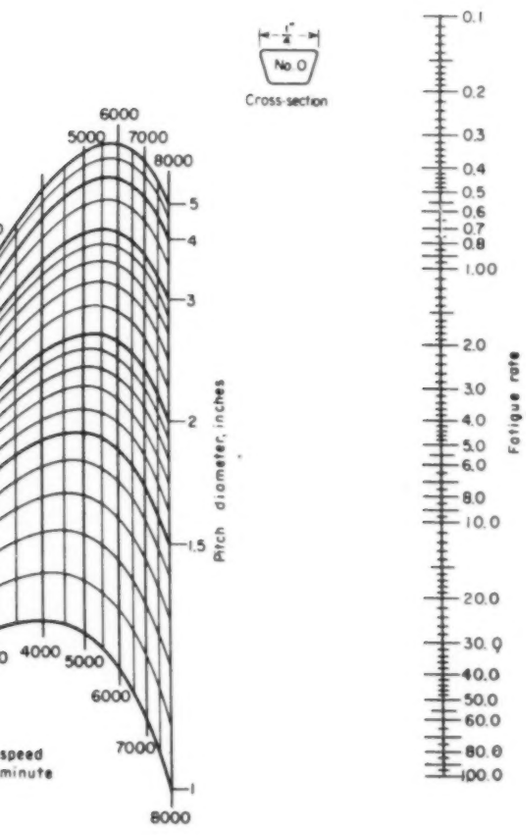
three variables are combined into the effective wheel horsepower. The bending stress developed in the belt when it is on the sheave is inversely proportional to the pitch diameter of the sheave. The stress due to centrifugal force is proportional to the square of the belt speed.

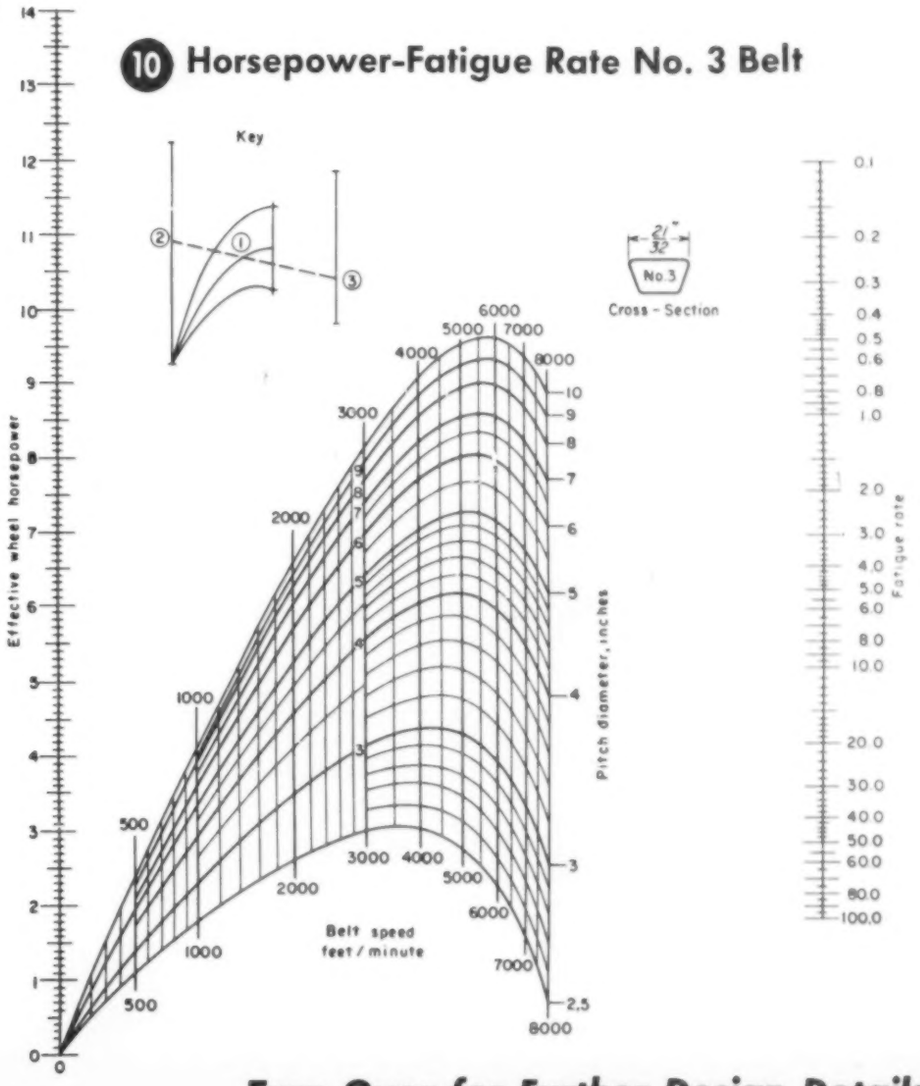
The following Horsepower-Fatigue Rate nomograms are constructed to give the length, in inches, of a belt which would give 100 hours' service under the peak stress from the above factors. This is the "Fatigue Rate." Belt life is proportional to belt length. Dividing the belt length required for the drive by the total of the fatigue rates, therefore, gives the calculated belt life.



r-Fatigue Rate No. 0 Belt



10 Horsepower-Fatigue Rate No. 3 Belt



Turn Over for Further Design Details

TWO-WHEEL V-BELT DRIVE

11 Judging the Drive

If the Calculated Belt Life is	And the Belt Cross-Section is:		
	"Best" Cross-Section	Smaller than "Best" Cross-Section	Larger than "Best" Cross-Section
Less than the Acceptable Belt Life	Drive is not good enough. Redesign the drive with larger wheels.*	Drive is not good enough. Find Calculated Belt Life For "Best" Cross-Section.	Drive is not good enough. Find Calculated Belt Life for "Best" Cross-Section.
Between 1 and 1⅓ times the Acceptable Belt Life	Drive is satisfactory. Go ahead with job: Check sheave grooves, take-up, etc.	Drive is satisfactory. Go ahead with job: Check sheave grooves, take-up, etc.	Drive can use a smaller belt and still be satisfactory; Find Calculated Belt Life for "Best" Cross-Section.
More than 1⅓ times the Acceptable Belt Life	Drive is better than it needs to be. 1. Find Calculated Belt Life for smaller cross-sections. 2. Redesign with smaller wheels.	Drive is better than it needs to be. Find Calculated Belt Life for next smaller cross-section.	Drive is better than it needs to be. 1. Find Calculated Belt Life for belts with smaller than "Best" Cross-section. 2. Use "Best" cross-section and redesign with smaller wheels.

*To redesign with larger wheels to get a drive with acceptable belt life, proceed as follows:

(1) Multiply the fatigue rate at the small sheave by the ratio of the calculated belt life of the drive, as already determined, to the acceptable belt life. This gives the small sheave fatigue rate that will give a new calculated belt life approximately equal to the acceptable belt life.

(2) On the Horsepower-Fatigue Rate nomogram for the belt cross-section you are using, draw a light line from the effective wheel horsepower to the revised small sheave fatigue rate you just calculated. From the original small sheave pitch diameter and its rpm, calculate the belt speed and locate the pitch diameter-belt speed point on the chart. With this as the starting point, plot a few more pitch diameter-belt speed points, using increased pitch diameters and the same rpm each time. Where this plotted curve intersects the line drawn from the effective horsepower to the fatigue rate is the indicated new size of small sheave to use.

The curve of constant rpm-pitch diameter-belt speed can be plotted quickly with the help of a slide rule. Simply set the slide to indicate ratio of original pitch diameter to its corresponding belt speed in feet per minute. This ratio will be constant for all pitch diameters. Select the pitch diameters off of the one scale and read the belt speed on the scale immediately below it.

(3) Having found the new small sheave diameter, make the large sheave diameter greater in the same proportion as originally. Then proceed as before and calculate the belt life for the revised diameter. It should figure out to be slightly more than the acceptable belt life.

(4) Check to be sure the large diameters will fit in the space available.

(See other side for initia

WEIGHING AND R

1: Will the drive be satisfactory?_____With wha

2: If unsatisfactory: Can the drive be redesigned with

Can it use more than one belt?___

Can wheel groupings be rearrang

If any of these are practical possibilities, make a
If not, consult the engineers of the V-Belt manufactur

After the diameters of the sheaves have been checked, proceed as follows:

FITTING THE

1: Sheave Groove Dimensions:

12

Wheel	Top Width	Sheave Groove Angle	Groove Depth Min.
Drive N 1	±	deg ±	
Drive R	±	deg ±	Min.

2: Effective Outside Diameters (Effective O.D.'s)

	Drive N	
Pitch Diameter		
± P.D. to effective O.D.*		
Effective O.D.		
Adjusted effective O.D.**		

*Add for a sheave, subtract for a flat pulley.

**Adjust the effective O.D.'s to the nearest convenient inch fraction if desirab

3: Take-up Provision: L_{max}_____; L_{min}_____; Take-

(15) Required for Installation_____; For Take-up___

IVE DESIGN WORKSHEET CONTINUED

for initial design)

AND REVISING

With what cross-section?_____

ed with different wheels?_____

belt?_____

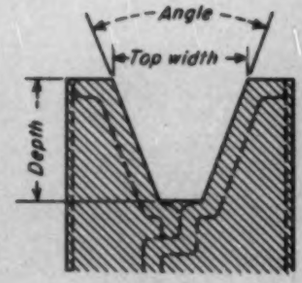
earranged into different drives?_____

make a new layout, and check out the new drive.
nufacturer.

e been definitely established and the belt size

THE BELT

13



Groove Depth Min.	Flat Pulley Face Width
Min.	

)

	Drive R

if desirable.

Take-up Available_____

-up_____; Total_____

14 Belt Length Variations

The effective outside lengths of V-Belts are subject to manufacturing variations. The length is also subject to variation from the effect of humidity on the textile components of the belt. The tolerance in the effective outside length is given in the following table. These tolerances will apply to belts produced by nearly all manufacturers. This table also shows outside lengths which are considered standard by almost all manufacturers.

CHECKING BELT LENGTH AND TAKE-UP PROVISION

Using the belt length formula

$$L = 2C + 1.57\,(D + d) + \frac{(D-d)^2}{4C}$$

and using for D and d the effective outside diameters instead of pitch diameters, calculate the effective belt lengths with the movable wheel in each extreme position, $L\ max$ and $L\ min$. The difference $L\ max - L\ min$ is the total belt length available for installing the belt and take-up for wear and stretch.

From $L\ max$ subtract the length to be allowed for take-up, as given in the following Table. This gives the effective length of the longest belt that can be used.

With the longest usable belt established, select the next shorter standard effective belt length, from which subtract $L\ min$. This gives the belt length allowance for installation. Compare this with the corresponding figure given in the table. If allowance is sufficient, the arrangement is satisfactory; if not, the take-up arrangement will have to be changed.

Standard Lengths and Tolerances

Nominal Outside Length Inches	Belt Cross Section				Effective Outside Length Tolerance Inches
	0	1	2	3	
8-13*	x				+ 1/8, − 3/8
14-17*	x	x			+ 1/8, − 3/8
18-20*	x	x	x		+ 1/8, − 3/8
21-24*		x	x		+ 1/4, − 3/8
25-50*		x	x	x	+ 1/4, − 3/8
52-60**		x			+ 1/4, − 3/8
51-60*			x	x	+ 1/4, − 3/8
61-79*			x	x	+ 5/16, − 11/16
80-100**			x	x	+ 3/8, − 7/8

*Inclusive. Standard lengths are every inch.
**Inclusive. Standard lengths are every two inches.

15 How to Obtain Sufficient Take-Up

There are three possibilities to consider:

(1) The drive may have enough allowance for both installation and take-up, except that the gap between the longest belt length which can be used and the next shorter standard belt length doesn't leave enough allowance for installation. In this case, try to shift both the minimum and maximum center locations to eliminate the gap between the longest belt length that can be used for the drive and the next shorter standard belt length.

(2) If the total allowance for both installation and take-up is less than the sum of the allowances given in Table at right, start with the standard belt length which you selected, and try to arrange so that the maximum center distance will provide the required amount of take-up allowance and the minimum center distance will allow the correct installation allowance.

(3) If neither of these possibilities can be managed, you may want to consider using an idler for take up. (See reference note (17) for instructions on designing such a drive.)

Standard Belt Length Allowances for Installation and Take-Up
All dimensions in inches

Nominal Length, Inches	Allowance for Installation for Various Belts				Allowance for Take-up All Cross-Sections
	0	1	2	3	
8-17.99	3/4	1 1/4			1
18-24.99	3/4	1 1/4	1 1/2		1
25-37.99		1 1/2	1 1/2	2	1
38-60.99		1 1/2	1 3/4	2	1 1/2
61-79.99			2	2 1/4	2 1/4
80-100			2 1/4	2 1/2	3

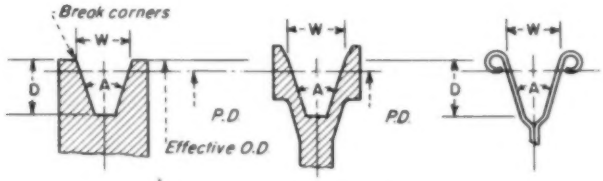
(15) Required for Installation_____; For Take-up_

12 Belt and Groove Dimensions

ALL DIMENSIONS IN I

Cross Section	Nominal Top Width by Thickness	Effective Outside Diameter	Degrees Groove Angle ± 1 deg	STANDAR W	STANDAR D Min.
0 (2L)	1/4 x 5/32	Under 1.5 1.5–1.99 2.0–2.5 Over 2.5	32 34 36 38	0.240 0.243 0.246 0.250	0.250
1 (3L)	3/8 x 7/32	Under 2.2 2.2–3.19 3.2–4.2 Over 4.2	32 34 36 38	0.360 0.364 0.368 0.372	0.406
2 (4L)	1/2 x 5/16	Under 2.65 2.65–3.24 3.25–5.65 Over 5.65	30 32 34 38	0.485 0.490 0.494 0.504	0.490
3 (5L)	21/32 x 3/8	Under 3.95 3.95–4.94 4.95–7.35 Over 7.35	30 32 34 38	0.624 0.630 0.637 0.650	0.580

Groove Top Width Tolerance: Single Groove: ± 0.010 Multiple Groov



Standard Grooves

13 Flat Pulleys

When using a flat pulley, see reference note (16), subtract from the pitch diameter the quantity "b" from the table at right to obtain the flat pulley O.D. The "effective outside diameter" will be the flat pulley O.D. plus the dimension given in column "a" in the accompanying table. This figure is twice the nominal belt thickness.

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Two-Wheel V-BELT DRIVE Design Worksheet

BY
SPENCER WORLEY
APPLICATION ENGINEER
GATES RUBBER COMPANY

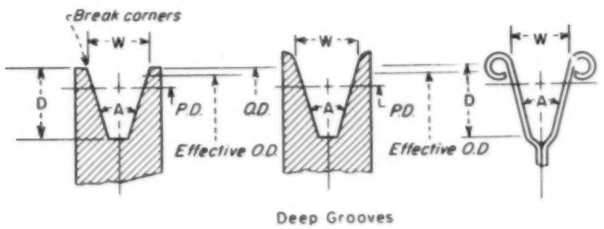
ake-up_____; Total_____

S

IONS IN INCHES

SHEAVES						
STANDARD GROOVES				DEEP GROOVES		
	D Min.	P.D. to Effective O.D.	W	D Min.	P.D. to Effective O.D.	P.D. to O.D.
	0.250	0.10	0.286 0.292 0.298 0.304	0.328	0.10	0.33
	0.406	0.15	0.432 0.441 0.449 0.458	0.531	0.15	0.45
	0.490	0.20	0.568 0.579 0.589 0.611	0.645	0.20	0.56
	0.580	0.30	0.720 0.734 0.747 0.774	0.760	0.30	0.71

ple Groove: ± 0.001



Deep Grooves

Dimensions For Flat Pulleys

Belt Cross Section	a Twice Nominal Belt Thickness	DISTANCE FROM PITCH DIAMETER TO		Min. Face Width inches
		b Inside of Belt	b Outside of Belt	
0	5/16	0.23	0.08	0.50
1	7/16	0.33	0.11	0.75
2	5/8	0.41	0.15	1.00
3	3/4	0.49	0.20	1.25

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16 V-Flat Drives

A drive using a small grooved sheave and a large flat pulley is called a "V-flat" drive. In general, such drives are practical when the ratio (D-d)/C is equal to, or greater than, 0.5. Such a drive may offer some advantages. If the (D-d)/C ratio is sufficiently large, a V-flat drive can be designed by considering these additional points:

Factor "G." After finding Factor "G" for the small sheave, also find Factor "G" for the flat pulley. To do this: Subtract the corrected arc of contact at the small sheave from 330°. This gives the corrected arc of contact on the flat pulley. Use this in reference (4) with the flat pulley curve. Use the smaller Factor "G" in finding effective wheel horsepower.

Use flat pulley data given in the table with reference note (13), when fitting the belt.

17 Drive with Two Loaded Wheels and Idler Take-Up

Idler location must provide for three to four per cent change in belt length. It should be placed on the slack side of the drive, if possible. The diameter of the idler, if it runs on the inside of the belt, should be somewhere between the diameters of the other sheaves. The diameter of an idler running on the back of the belt should be ½ larger than the diameter which would be used on the inside of the belt.

A layout will be necessary to determine arc of contact at each wheel and belt length. Belt tangent lengths between wheels may be measured, and lengths around each wheel may be calculated, and the results added to determine the required belt length.

To find Factor "G" use the smaller of the arcs of contact at the loaded wheels, subtract 15 deg and proceed as for a two-wheel drive.

Finding the effective wheel horsepower and "best" cross-section depends on whether the idler will be on the tight or the slack side of the drive.

Idler on the Tight Side of the Drive—Design horsepower divided by Factor "G", as determined above, gives the effective wheel horsepower at driveR, driveN, and idler—all three. The "best" cross section is determined by the point corresponding to the effective wheel horsepower and the rpm of the smallest wheel. (If the idler is on the outside of the belt, consider its diameter as ¾ its actual diameter to compensate for additional stresses in bending the belt backward, and its rpm as 4/3 its actual rpm.)

Idler on the Slack Side of the Drive—In this case, design horsepower divided by Factor "G" gives the effective wheel horsepower at the two loaded wheels only. Subtract from this 80 per cent of the design horsepower to get the effective wheel horsepower at the idler. The "best" cross-section will be determined by the effective wheel horsepower and rpm of the smaller loaded wheel. If, however, the idler is smaller than either loaded wheel, and the effective wheel horsepower-rpm point for the smaller loaded sheave is near the top of the "best" cross-section area, check both cross-section indicated and the next smaller one.

Again, consider the diameter of an idler on the outside of the belt as ¾ its actual diameter, and the rpm as 4/3 its actual rpm.

Fatigue Rate—Find the fatigue rate for all three wheels, using ¾ the idler diameter if it runs on the outside of the drive. The calculated belt life is found by dividing belt length by the total fatigue rate.

Effective O.D. of a Flat Pulley Idler – If pulley runs inside belt, effective O.D. would be flat pulley O.D. plus dimension given in column "a" – See reference note (13).

If pulley runs outside the belt, pulley O.D. is also the effective O.D.

Table III—Judging the Drive

If the Calculated Belt Life is	And the Belt Cross-Section is:		
	"Best" Cross-Section	Smaller than "Best" Cross-Section	Larger than "Best" Cross-Section
Less than the Acceptable Belt Life	Drive is not good enough. Redesign the drive with larger wheels.	Drive is not good enough. Find Calculated Belt Life for "Best" Cross-Section.	Drive is not good enough. Find Calculated Belt Life for "Best" Cross-Section
Between 1 and 1⅓ times the Acceptable Belt Life	Drive is satisfactory. Go ahead with job: Check sheave grooves, take-up, etc.	Drive is satisfactory. Go ahead with job: Check sheave grooves, take-up, etc.	Drive can use a smaller belt and still be satisfactory; Find Calculated Belt Life for "Best" Cross-Section.
More than 1⅓ times the Acceptable Belt Life	Drive is better than it needs to be. 1. Find Calculated Belt Life for smaller cross-sections. 2. Redesign with smaller wheels.	Drive is better than it needs to be. Find Calculated Belt Life for next smaller cross-section.	Drive is better than it needs to be. 1. Find Calculated Belt Life for belts with smaller than "Best" Cross-Section. 2. Use "Best" cross-section and redesign with smaller wheels.

already determined, to the acceptable belt life. This gives the small sheave fatigue rate that will give a new calculated belt life approximately equal to the acceptable belt life.

(2) On the "Horsepower-Fatigue Rate" nomogram for the belt cross-section you are using, draw a light line from the effective wheel horsepower to the revised small sheave fatigue rate you just calculated. From the original small sheave pitch diameter and its rpm, calculate the belt speed and locate the pitch diameter-belt speed point on the chart. See Fig. 8. With this as the starting point, plot a few more pitch diameter-belt speed points, using increased pitch diameters and the same rpm each time. Where this plotted curve intersects the line drawn from the effective horsepower to the fatigue rate is the indicated new size of small sheave to use.

The curve of constant rpm-pitch diameter-belt speed can be plotted quickly with the help of a slide rule. Simply set the slide to indicate ratio of original pitch diameter to its corresponding belt speed in feet per minute. This ratio will be constant for all pitch diameters. Select the pitch diameters off of the one scale and read the belt speed on the scale that is immediately below it.

(3) Having found the new small sheave diameter, make the large sheave diameter greater in the same proportion as originally. Then proceed as before and calculate the belt life for the revised diameter. It should figure out to be slightly more than the acceptable belt life.

(4) Check to be sure the larger diameters will fit in the space.

When the drive is overdesigned, a similar procedure is followed. The correct design will have the longest life and will be the most economical.

Opposite this page is a folded "Two-Wheel V-Belt Drive Design Worksheet." Top center on each face of this worksheet, with tinted background, is a form for calculating the drives. Starting in the upper left-hand corner is given the explanation, data, and procedure to be followed.

Additional copies of this form are obtainable upon request to the editor of Product Engineering.

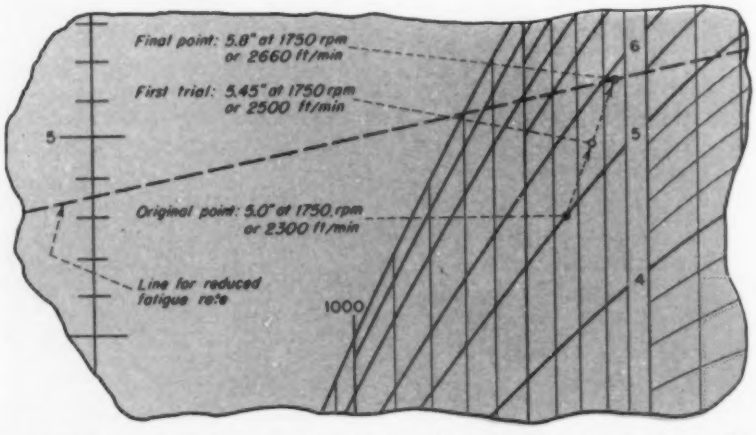

Fig. 8—Indicated procedure for using the chart, such as in Fig. 7, for determining the new small sheave diameter that will correct the drive if it has been under designed.

Pressure Surges in Hydraulic Circuits

Water hammer in hydraulic piping and method of calculating the amplitude of pressure waves that result both from rapid and from gradual valve closure of simple and of compound pipe lines. Capacity of air accumulator required to suppress pressure surge. Application of equations is demonstrated by examples.

NOTATION

a	= velocity of pressure wave, ft per sec
a_E	= effective velocity of pressure wave, ft per sec
A	= cross-sectional area of pipe, sq in.
A_o	= area of throttling orifice before closure, sq in.
c	= velocity of sound, ft per sec
C_D	= coefficient of discharge
D	= inside diameter of pipe, in.
E	= modulus of elasticity of pipe material, psi
F	= force, lb.
g	= gravitational acceleration, 32.2 ft per sec^2
K	= bulk modulus of fluid medium, psi
L	= length of pipe, ft
m	= mass, slu g
N	= $T/(2L/a)$ = number of pressure wave intervals during time of valve closure
p	= normal static fluid pressure immediately upstream of valve when the fluid velocity is V, psi absolute
Δp	= amplitude of pressure wave, psi
p_{MAX}	= maximum static pressure immediately up stream of valve, psi absolute
p_d	= static pressure immediately downstream of the valve, psi absolute
Q	= volume rate of flow, cu ft per sec
t	= wall thickness of pipe, in.
T	= time in which valve is closed, sec
v	= fluid volume, cu in.
V_A	= air volume, cu in.
V	= normal velocity of fluid flow in pipe with valve wide open, ft per sec
V_E	= equivalent fluid velocity, ft per sec
V_n	= velocity of fluid flow during interval n, ft per sec
W	= work, ft lb
γ	= specific weight, lb per cu ft
ϕ_n	= coefficient dependent upon the rate of change in orifice area and discharge coefficient
τ	= period of oscillation of air cushion in a sealed chamber, sec

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Hydraulic Engineer,
Aerojet-General Corporation

MINIMIZING WATER HAMMER or pressure surges, which result from either acceleration or deceleration of the flow of a mass of fluid in hydraulic circuits, presents a frequently occurring design problem to the hydraulic engineer. This problem is probably one of the more complex met with in hydraulics. Fortunately when understood, the phenomenon of water hammer readily lends itself to mathematical analyses.

Either acceleration or deceleration of the flowing mass of fluid in a hydraulic circuit results in elastic surges that frequently cause damage to the pipe line and to the components of the hydraulic system.

In the solution of hydraulic flow problems, liquids are generally considered to be incompressible. In pressure surge analyses, however, the elasticity of the fluid and that of the pipe material are of utmost significance.

For a homogeneous solid material, the relation between stress and strain within the elastic limit is defined by the modulus of elasticity E, or the ratio of the unit stress to the corresponding elongation per unit length. Values of E for some pipe materials are:

Material	E
Aluminum	10,700,000
Copper	17,000,000
Stainless steel	29,000,000

For a liquid, the relation between change of pressure and the corresponding change in volume is defined by the bulk modulus K, or the ratio of incremental change in unit pressure to the corresponding change in vol-

SEQUENCE OF EVENTS IN ONE CYCLE OF A PRESSURE SURGE

(A) With fluid flowing in normal direction, pressure wave starts at and travels away from valve immediately after closure, and pipe expands.

(B) Fluid flow is opposite to normal, pressure wave travels back to closed valve, and pipe contracts to normal size.

(C) Fluid flow is still opposite to normal, pressure wave is reflected away from closed valve, and pipe contracts to less than normal size.

(D) Fluid flow is in normal direction, pressure wave returns to closed valve, and pipe returns to normal size.

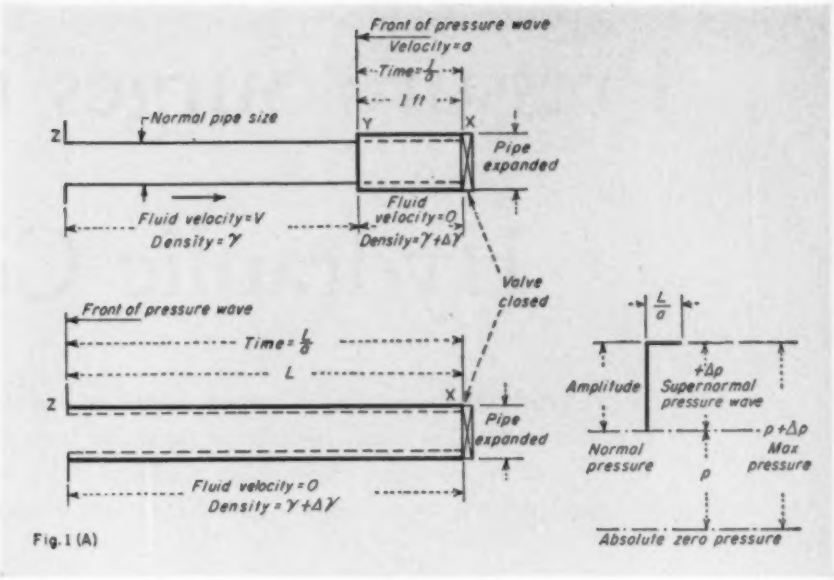


Fig. 1 (A)

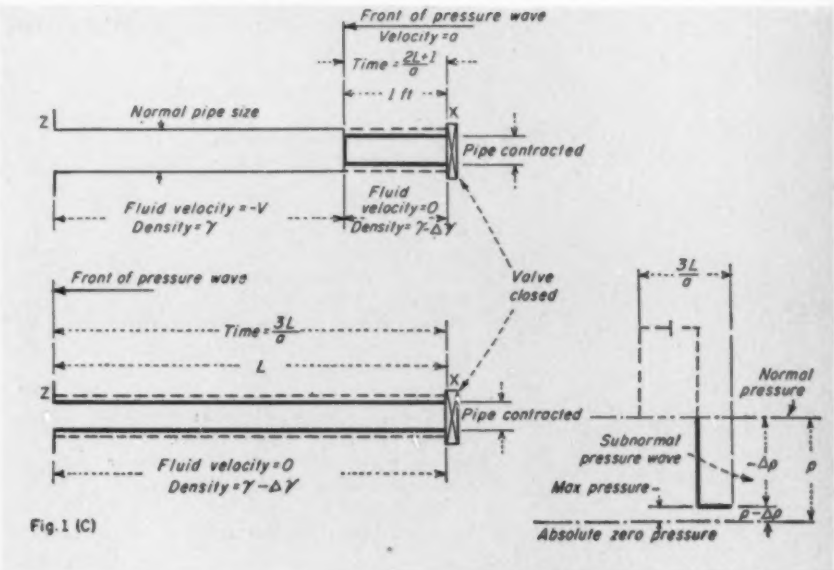


Fig. 1 (C)

ume per unit volume, or as the value

$$K = -dp/(dv/v) = -v\,(dp/dv) \quad (1)$$

the negative sign indicates that volume decreases as pressure increases.

Values of K for oil and water at normal operating temperatures in hydraulic circuits are generally taken as:

Medium	K
Oil	250,000
Water	300,000

A definite relationship exists between the bulk modulus K and the velocity of sound in a medium:

$$c = 68.094\sqrt{K/\gamma} \quad (2)$$

or $$K = 2.157 \times 10^{-4}\,\gamma c^2 \quad (3)$$

SEQUENCE OF EVENTS

Assume that fluid is flowing with a constant velocity V through a pipe of length L, as indicated in Fig. 1(A), and the valve at X is closed suddenly.

At the instant the valve is closed, a lamina of fluid adjacent to the valve is brought to rest. The kinetic energy of this lamina of fluid is converted into pressure energy that compresses the lamina and stretches the portion of the pipe wall surrounding the lamina. Immediately upstream of the valve, the pressure is increased by an amount Δp above the normal pressure p. The velocities of adjacent laminas of fluid are then successively decreased to zero and their kinetic energy converted into pressure energy.

A pressure wave having a velocity a and an amplitude of Δp, therefore, travels up the pipe from X to Z. After l/a sec the column of fluid XY (l ft long) is brought to rest, during which time the kinetic energy in this column is converted into pressure energy, meanwhile the pressure in column YZ is still normal and the fluid in YZ is still flowing with its initial

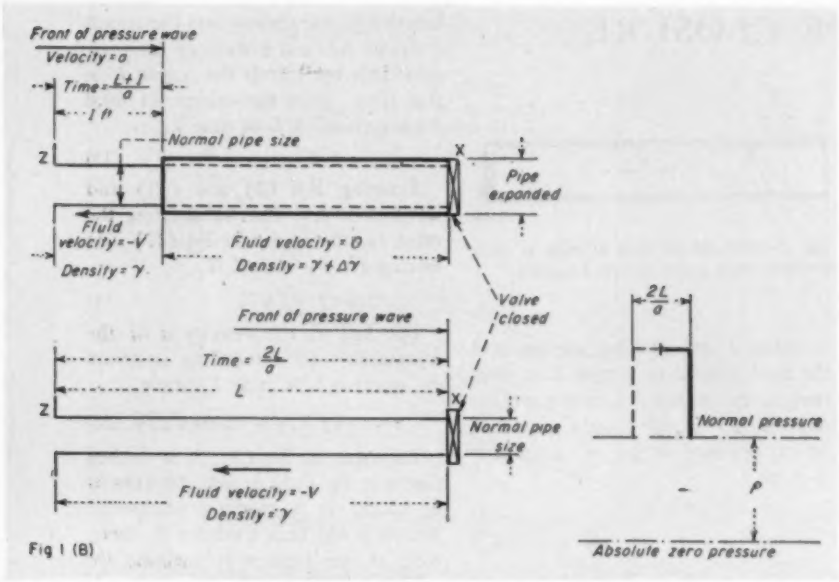


Fig 1 (B)

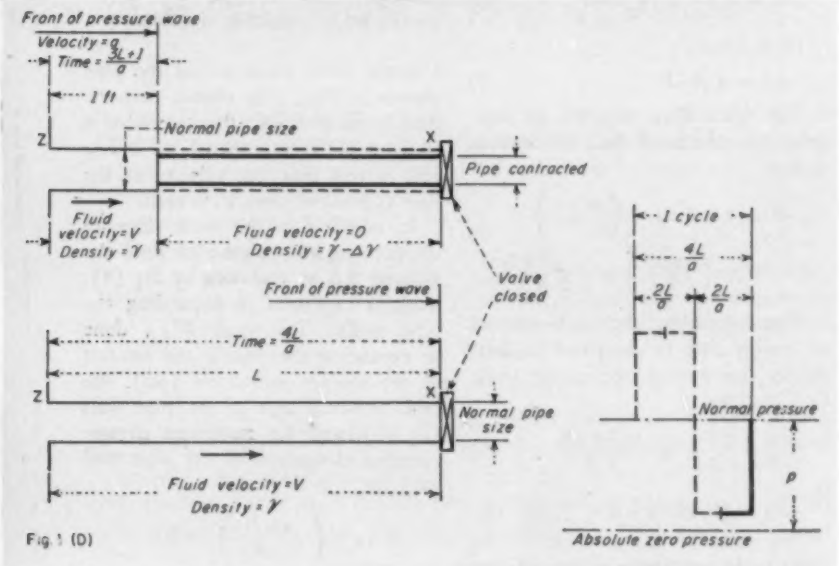


Fig 1 (D)

velocity V. After L/a sec, the total column XZ of fluid will be brought to rest; at this instant the hydrostatic pressure throughout the pipe is supernormal, the entire pipe is expanded, and the column XZ of fluid is compressed to a density greater than normal.

In Fig. 1(B) are indicated the conditions that prevail the instant immediately after the velocity of the entire mass of fluid is reduced to zero and no kinetic energy is available to maintain the state of supernormal pressure.

At this instant, the pressure of the lamina of fluid at Z immediately returns to normal, the pipe wall surrounding this lamina contracts to normal size, and the fluid in this lamina expands.

A wave of pressure decrease proceeds from Z to X with a velocity a, while fluid stored in the space created by the earlier expansion of the pipe and compression of the fluids, Fig. 1(A), is discharged upstream with velocity $-V$. After $2L/a$ sec, the pressure wave reaches the closed valve, the entire pipe is returned to normal size, the fluid is expanded to its normal density, the hydrostatic pressure throughout the pipe is normal, and the column XZ of fluid flows toward Z with $-V$ velocity.

In Fig. 1(C) are indicated the conditions that accompany the flow of fluid toward Z. As a result of the fluid inertia and velocity in the reversed direction, the fluid tends to separate from the end of the pipe at X. The hydrostatic pressure of the lamina of fluid immediately adjacent to the closed valve drops to subnormal, the velocity of the lamina is reduced to zero, the pipe contracts, and the fluid expands.

A wave of subnormal pressure then proceeds upstream with velocity a, while adjacent laminas of fluid are successively brought to rest. After $3L/a$ sec, the pressure wave reaches the upstream end of the pipe at Z, the velocity of the entire column of fluid is reduced to zero, the pipe wall is contracted throughout the length of the pipe, the fluid is expanded to a density less than normal, and the hydrostatic pressure throughout the pipe is subnormal.

In the lower view of Fig. 1(C), the total column of fluid is shown at rest again, the static pressure of the lamina of fluid at Z, Fig. 1(D), immediately returns to normal, the pipe wall expands to normal size, and the fluid compresses. A wave of normal pressure proceeds from Z to X with velocity a, while fluid flows with velocity V into the space created by the expansion of the pipe and compression of the fluid.

After $4L/a$ sec, the pressure wave reaches the closed valve, the entire pipe is returned to its initial size, the column of fluid is compressed to its initial density, the hydrostatic pressure is returned to normal throughout the pipe, and the fluid in the pipe flows toward the closed valve with velocity V. These events complete a cycle in which the pressure wave travels away from and back to valve, then is reflected away from and returns to valve.

Instantly another similar cycle starts. If there were no resistance to flow, the surge phenomenon would continue to repeat itself indefinitely with undiminishing intensity. As a result of hydraulic friction, however, some energy is dissipated into heat and the initial velocity V decreases slightly throughout the cycle. The amplitude of the pressure surges, therefore, successively diminishes until the oscillations eventually are damped out.

RAPID VALVE CLOSURE

In a hydraulic system, when the velocity of the flowing fluid is changed by opening or closing a valve, pressure surges result. The amplitude of the pressure surge is a function of the rate of change in velocity of the mass of fluid.

A pipe through which fluid is flowing with a velocity of V is shown in Fig. 2. When the valve at the end of the pipe is closed rapidly, the kinetic energy of the moving mass of fluid is changed into pressure energy. A sudden rise in pressure in excess of the normal static pressure thus results.

Where

ΔT = increment of time in closing valve, sec
ΔV = decrease in velocity in time ΔT, ft per sec
Δp = resulting pressure rise, psi
m = mass of fluid the velocity of which is changed, slugs
A = cross-sectional area of pipe, sq in.

then Newton's second law gives

$$\text{Force} = -\Delta pA = m(\Delta V/\Delta T), \text{ lb} \quad (4)$$

in which the negative sign indicates that an increase in Δp corresponds to a decrease in ΔV.

If the velocity of the mass m could be reduced from V to zero instantaneously, the pressure resulting from the instantaneous change in velocity would be infinite. In practice, however, such an instantaneous change is impossible to achieve, and during the time of valve closure a series of pressure waves is created that travel back and forth between the pipe extremities.

When complete closure is effected before the first pressure wave has time to return to the valve, that is, if closure is effected in less than the time required for the wave to make one round trip between the pipe extremities, the resulting pressure rise is the same as if the valve had been instantaneously closed except for the effect of the compressibility of the fluid and the elasticity of the pipe. This type of closure will be referred to as rapid closure and occurs when the closing time T is equal to or less than $2L/a$ seconds.

INELASTIC PIPE. Assume that the pipe in Fig. 2 is inelastic, that the fluid is compressible, and that the valve closure is instantaneous. The kinetic energy of the moving mass of fluid then

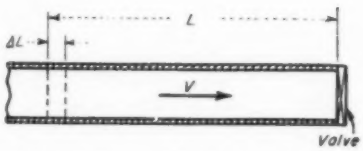


Fig. 2—Column of fluid in pipe is compressed when valve is closed rapidly.

is changed into pressure energy, and the fluid column of length L is compressed the amount ΔL by the average increase ΔF of the force F produced by a pressure surge of amplitude Δp, or

$$\Delta F = \Delta pA/2, \text{ lb} \quad (5)$$

From Eq (1), the bulk modulus is

$$K = \frac{\Delta p\, AL \times 12}{A\, \Delta L \times 12} = \frac{\Delta pL}{\Delta L} \quad (6)$$

from which

$$\Delta L = \Delta pL/K \quad (7)$$

The work $W_{\Delta L}$ required to compress the column of fluid the amount ΔL is

$$W_{\Delta L} = \Delta F\, \Delta L = \left(\frac{\Delta p\, A}{2}\right) \times \left(\frac{\Delta pL}{K}\right) = \frac{(\Delta p)^2\, AL}{2K} \quad (8)$$

Then neglecting the small amount of energy that is dissipated in heat during this process, the energy equation becomes

$$\frac{\gamma A L V^2}{144 \times 2g} = \frac{(\Delta p)^2 A L}{2K} \quad (9)$$

$$\Delta p = (V/12)\sqrt{\gamma K/g} \quad (10)$$

The value of Δp as given by Eq (10) is the amplitude of the pressure wave that results from the rapid change in the velocity of the fluid from V to zero in an inelastic pipe.

From Eq (4) it follows that

$$\Delta pA = (\gamma AL/144g)(V/T) \quad (11)$$

$$L = (144\, \Delta p\, g/\gamma)(T/V) \quad (12)$$

In time T, the column of fluid of length L is compressed into the length L minus ΔL and a wave of compression therefore travels the length L in that time. Since the column of fluid is compressed ΔL in time T,

$$\Delta L = TV \quad (13)$$

Equating Eqs (7) and (13) and solving for Δp, then substituting the value found for Δp in Eq (12) and solving for the ratio L/T,

$$L/T = 12\sqrt{g K/\gamma} \quad (14)$$

But L/T is the velocity a of the compression wave traveling upstream the distance L in time T, hence

$$a = 12\sqrt{g K/\gamma} = 68.094\sqrt{K/\gamma} \quad (15)$$

Referring to Eq (2), it is evident that a in Eq (15) is also the velocity of sound in a medium of specific weight γ and bulk modulus K, therefore, if the pipe were inelastic the velocity of the pressure wave would equal that of sound in the fluid.

ELASTIC PIPE. Assume that the pipe shown in Fig. 3 is elastic, that the fluid is compressible, that the valve is closed rapidly such that $T \leqq 2L/a$ and in this time the velocity of the fluid is reduced from V to zero.

In addition to the work done in compressing the column of fluid the amount ΔL as evaluated by Eq (8), work is expended in expanding the pipe walls. The work $W_{\Delta D}$ done in expanding the pipe is the product of the average unit stress (psi), the cross sectional area of the pipe wall (sq in.), and the maximum circumferential elongation of the pipe wall (ft), or

$$W_{\Delta D} = \left(\frac{\Delta p\, D}{2 \times 2t}\right)(12\, L\, t) \times \left(\frac{\Delta p\, D}{2t} \cdot \frac{\pi D}{12E}\right) = \frac{\pi (\Delta p)^2 D^2 L}{8Et} = (\Delta p)^2 A D L/2Et \quad (16)$$

Neglecting the energy stored in the pipe as a result of longitudinal elonga-

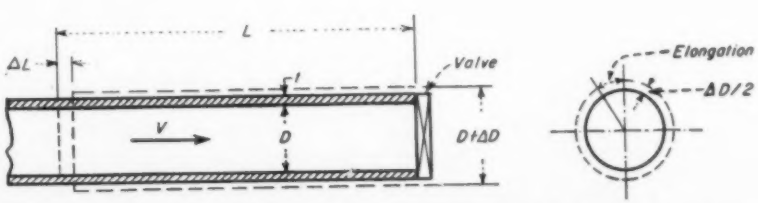


Fig. 3—Circumferential elongation of pipe when fluid velocity suddenly becomes zero.

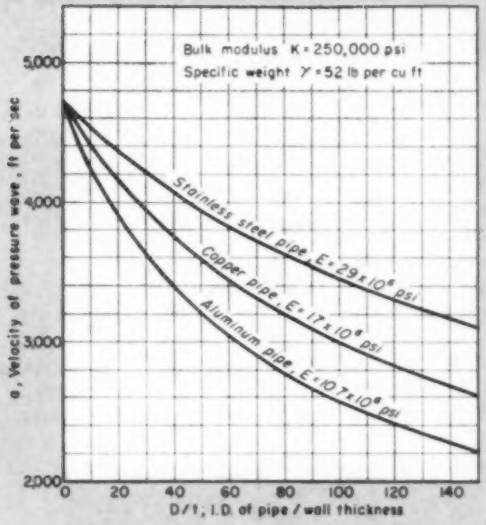


Fig. 4—Velocity of pressure wave in oil column in pipe of different diameter to wall thickness ratios.

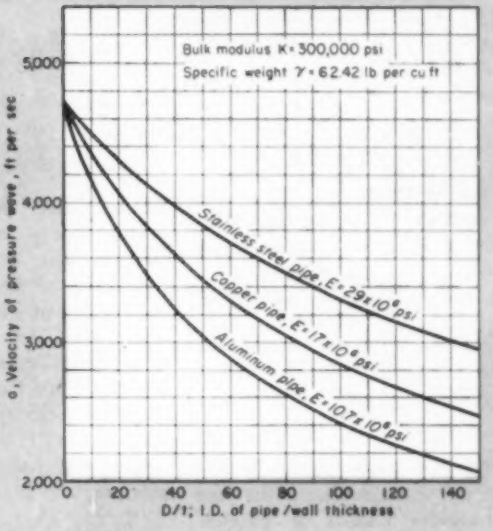


Fig. 5—Velocity of pressure wave in water column in pipe of different diameter to wall thickness ratios.

tion and also neglecting the energy dissipated in heat, and denoting the pressure energy stored in the compressed column of fluid by $W_{\Delta L}$, the energy equation becomes

$$m V^2/2 = W_{\Delta L} + W_{\Delta D}$$

$$\text{or } \frac{\gamma A L V^2}{144 \times 2 g} = \frac{(\Delta p)^2 A L}{2 K} + \frac{(\Delta p)^2 A D L}{2 E t}$$

or

$$\Delta p = \frac{68.094 \gamma V}{144 g \sqrt{\gamma [(1/K) + (D/E t)]}} \quad (17)$$

When $T \leqq (2L/a)$, the value of Δp given by Eq (17) is the amplitude of the pressure wave resulting from a rapid valve closure.

After a small closing movement of the valve, a pressure wave travels from the valve upstream with velocity a. In any differential element of time dT, this wave will have a differential pressure rise $d\Delta p$, and the wave will have traveled a distance

$$L = a\, dT$$

In addition, from Eq (4)

$$-A\, d\Delta p = \frac{\gamma A a\, dT}{144 g} \left(\frac{dV}{dT}\right)$$

which reduces to

$$-d\Delta p = \frac{\gamma a}{144 g} dV \quad (18)$$

Integration of Eq (18) between the limits of the normal velocity V and the reduced velocity V_R that results from partial valve closure gives the maximum pressure rise; hence

$$\Delta p = \frac{\gamma a}{144 g} (V - V_R) \quad (19)$$

Where p denotes the normal static pressure immediately upstream of the valve and p_{MAX} denotes the maximum pressure

$$p_{MAX} = p + \Delta p \quad (20)$$

If the velocity is changed from V to zero, the amplitude of the pressure wave is

$$\Delta p = \gamma a V/144g \quad (21)$$

Equating Eqs (17) and (21) gives

$$a = \frac{68.094}{\sqrt{\gamma [(1/K) + (D/Et)]}} \quad (22)$$

The value of a given by Eq (22) is the velocity of the pressure wave when both the fluid and the pipe are considered elastic.

The charts, Figs. 4 and 5, which are based on Eq (22), give the velocity of the pressure wave versus D/t ratios for an oil column and a water column and pipe of different materials. The application of the charts and the foregoing equations is demonstrated by the following examples.

EXAMPLE 1. Oil with a specific weight of 52 lb per cu ft and a bulk modulus of 250,000 psi flows at the rate of 40 U. S. gpm through a stainless steel pipe. The pipe is 40 ft long, 1.5 in. O.D, 1.402 in. I.D, 0.049 in. wall thickness, and has a modulus of elasticity E of 29×10^6 psi. The normal static pressure immediately upstream of the valve is 500 psi absolute. When the flow is reduced to zero in 0.015 sec by closing a valve at the end of the pipe, what is: (A) The velocity of the pressure wave; (B) the period of the pressure wave; (C) the amplitude of the pressure wave; and (D) the maximum static pressure at the valve.

SOLUTION:

(A) From Eq (22), the velocity of the pressure wave is

$$a = \frac{68.094}{\sqrt{52 [(1/25 \times 10^6) + (1.402/29 \times 10^6 \times 0.049]}} = 4228 \text{ ft per sec}$$

Alternate solution using Fig. 4:

$$D/t = 1.402/0.049 = 28.6$$

For stainless steel pipe having a D/t ratio of 28.6, the velocity a of the pressure wave is 4228 ft per sec.

(B) The time for the pressure wave to make one round trip between the pipe extremities, or one interval, is

$$2L/a = 2 \times 40/4228 = 0.0189 \text{ sec}$$

and the period of the pressure wave is

$$2 \times (2L/a) = 2 \times 0.0189 = 0.0378 \text{ se}$$

(C) Since the time of 0.015 sec for valve closure is less than the interval time $2L/a$ equal to 0.0189 sec, the pressure surge can be computed by Eq (21) for rapid valve closure.

The velocity of flow is

$$V = \frac{40 \times 231 \times 4}{60 \times \pi \times 1.402^2 \times 12}$$

$$= 8.3 \text{ ft per sec}$$

The amplitude of the pressure wave from Eq. (21) is

$$\Delta p = \frac{52 \times 4228 \times 8.3}{144 \times 32.2} = 393.5 \text{ psi}$$

(D) The resulting maximum static pressure immediately upstream of the valve from Eq (20) is

$$p_{MAX} = 500 + 393.5 = 893.5 \text{ psi abs}$$

EXAMPLE II. What would be the pressure rise in Example I if the pipe was aluminum instead of stainless steel?

SOLUTION: From Fig. 4, for aluminum pipe having a D/t ratio of 28.6, the velocity a of the pressure wave is 3655 ft per sec.

The time for one interval of the pressure wave is then calculated from

$$2L/a = 2 \times 40/3655 = 0.02188 \text{ sec}$$

Since the time of 0.015 sec for valve closure is less than the interval time $2\ L/a$ equal to 0.02188, the pressure rise can be computed by Eq (21) for rapid valve closure.

$$\Delta p = \frac{52 \times 3655 \times 8.3}{144 \times 32.2} = 340.2 \text{ psi}$$

and the resulting maximum static pressure at the valve is

$$p_{MAX} = 500 + 340.2 = 840.2 \text{ psi abs}$$

EXAMPLE III. What would be the pressure rise in Example I if the flow medium were water having a bulk modulus K of 300,000 psi and a specific weight of 62.42 lb per cu ft?

SOLUTION: From Fig. 5, for a stainless steel pipe having a D/t ratio of 28.6, the velocity a of the pressure wave is 4147 ft per sec.

The time for one interval of the pressure wave is

$$2L/a = 2 \times 40/4147 = 0.01929 \text{ sec}$$

Since the time of 0.015 sec for valve closure is less than the interval time $2L/a$ equal to 0.01929, the pressure rise can be computed by Eq (21) for rapid valve closure.

$$\Delta p = \frac{62.42 \times 4147 \times 8.3}{144 \times 32.2} = 463.4 \text{ psi}$$

and the maximum static pressure at the valve is

$$p_{MAX} = 500 + 463.4 = 963.4 \text{ psi abs}$$

GRADUAL VALVE CLOSURE

When the closing time T is greater than one interval $2L/a$, the pressure wave is reflected from the valve and travels again upstream with the velocity a. The number of pressure wave intervals during the time T of valve closure is

$$N = T/(2L/a) \tag{23}$$

and the amplitude of the pressure wave during any interval is proportional to the decrease in velocity during that interval. The total pressure change at any instant during the closing of the valve is the sum of the amplitudes (positive or negative) of the pressure waves produced up to that time. The fluid velocity V_n during any pressure wave interval is the normal velocity V minus the sum of the decreases in fluid velocity in the preceding intervals.

If during the nth interval the decrease in velocity is ΔV_n, then in accordance with Eq (19) the increase in pressure during the nth interval is

$$\Delta p_n = (\gamma a/144g)\, \Delta V_n \tag{24}$$

and the velocity of the fluid after the nth interval is given by

$$V_n = V - \sum_{i=1}^{i=n} \Delta V_i$$

$$= \phi_n \sqrt{\left(p + \sum_{i=n}^{i=1} \Delta p_i\right) - p_d} \tag{25}$$

in which p is the normal static pressure immediately upstream of the valve before valve closure when the fluid velocity is V, and ϕ_n is the flow coefficient of the valve at the nth interval, and p_d is the static pressure immediately downstream of the valve.

The sum of the terms included in parentheses under the radical sign in Eq (25) represents the static pressure immediately upstream of the valve when the fluid velocity is V_n. The second term in these parentheses represents the pressure rise, which is equal to the algebraic sum of the amplitude of the pressure waves, or

$$\sum_{i=n}^{i=1} \Delta p_i = \Delta p_n - \Delta p_{n-1} + \Delta p_{n-2} - \Delta p_{n-3} + \ldots \pm \Delta p_1 \tag{26}$$

In Eq (25), the term and its evaluation that represents the total decrease in velocity in n intervals is

$$\sum_{i=1}^{i=n} \Delta V_i = \Delta V_1 + \Delta V_2 + \Delta V_3 + \ldots + \Delta V_n \tag{27}$$

The value of the factor ϕ_n depends upon the rate of change in the area of the throttling orifice and in the change in the coefficient of discharge C_D. If the area of the throttling orifice before closure is A_o and the cross sectional area of the pipe is A, the volume rate of flow Q is

$$Q = \frac{AV}{144} = \frac{C_D A_o}{144} \times \sqrt{2g \frac{144\ (p - p_d)}{\gamma}} \tag{28}$$

From Eq (28) the fluid velocity is

$$V = 12 \sqrt{2g/\gamma}\ (A_o/A)\ C_D \sqrt{p - p_d} \tag{29}$$

which can be written in the form

$$V = \phi \sqrt{p - p_d} \tag{30}$$

hence

$$\phi = 12\ C_D\ (A_o/A)\ \sqrt{2g/\gamma}$$

$$= V/\sqrt{p - p_d} \tag{31}$$

and for the nth interval

$$\phi_n = 12\ C_{Dn}\ (A_n/A)\ \sqrt{2g/\gamma}$$

$$= V_n/\sqrt{p_n - p_{dn}} \tag{32}$$

For the nth interval, if the closing velocity of the valve and the rate of decrease in orifice area are uniform, and C_D is constant

$$\phi_n = [1 - (n/N)]\, \phi \tag{33}$$

substituting from Eq (23)

$$\phi_n = [1 - n\ (2L/aT)]\, \phi \tag{34}$$

With a value for ϕ_n determined from Eq (34), the pressure rise at any instant during the closing of the valve can be computed by solving Eqs (24) and (25) simultaneously.

The value of ϕ_n as given by Eq (34) is applicable only to uniform valve closure, that is, when the closing velocity of the valve and the decrease in orifice area are uniform. In practice, uniform valve closure is rarely attained.

The mathematical method presented, however, may also be applied to nonuniform valve closure because the factor ϕ_n appearing in Eq (25)

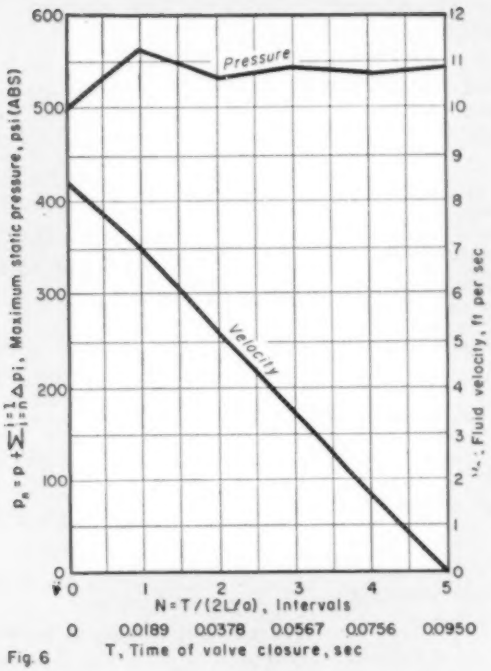

Pressure
Velocity
$p_d = p + \sum_{i=1}^{i=n} \Delta p_i$, Maximum static pressure, psi (ABS)
V_d, Fluid velocity, ft per sec
N = T/(2L/a), Intervals
T, Time of valve closure, sec

Fig. 6

Fig. 6—Plot of the solution of Example IV giving the static pressure immediately upstream of the valve and fluid velocity during valve closure.

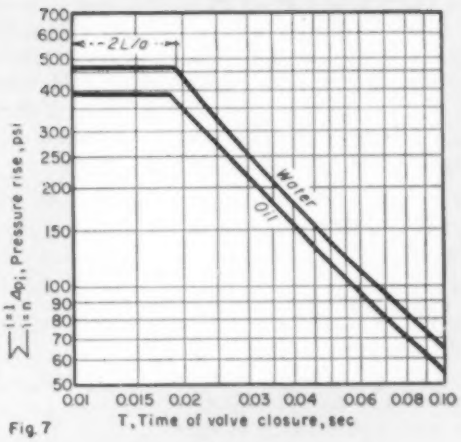


Fig. 7

Fig. 7—Pressure rise for different times of valve closure, Example I, in stainless steel pipe with oil and water as flow mediums.

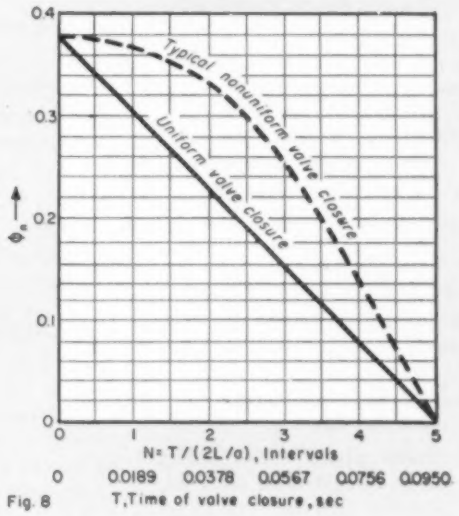


Fig. 8

Fig. 8—Values of valve coefficient ϕ_n, Example IV, at different times of valve closure; also a typical curve for nonuniform valve closure.

and defined by Eq (32) is a function of the closing characteristics of the valve. If great accuracy is required, it may be necessary to conduct a study of the hydraulic and mechanical closing characteristics of the specific valve to determine the proper value of ϕ_n with relation to the time of closure.

EXAMPLE IV: To demonstrate the application of the equations for gradual valve closure, assume that in Example I the valve closure is uniform and that closure takes place in 0.095 sec, and that the pressure p_d downstream of the valve is atmospheric or 14.7 psi abs. Find the resulting pressure rise?

SOLUTION: The time $2L/a$ of one interval, as calculated in Example I, is 0.0189 sec. Then from Eq (23), the total number of intervals N over which valve closure occurs is

$$N = 0.095/0.0189 = 5$$

As computed from Eq (3), page 147, *Product Engineering*, April 1951, "Calculating the Energy Losses in Hydraulic Systems", the pressure loss in the pipe at a flow rate of 40 U. S. gpm is about 4 psi. Since this loss is small, the normal static pressure p of 500 psi abs immediately upstream of the valve may be considered as constant regardless of the change in velocity during closing of the valve.

As previously determined, V is 8.3 ft. per sec, then the value of ϕ from Eq (31) is

$$\phi = 8.3/\sqrt{500-14.7} = 0.377$$

First Interval:

For the first interval, Eq (33) gives

$$\phi_1 = [1-(1/5)]\,0.377 = 0.302$$

and by Eqs (24) and (25)

$$\Delta p_1 = \frac{52 \times 4228}{144 \times 32.2} \Delta V_1 = 47.415\,\Delta V_1 \qquad (24A)$$

$$V_1 = 8.3 - \Delta V_1 = 0.302\sqrt{(500 + \Delta p_1) - 14.7} \qquad (25A)$$

Solving Eqs (24A) and (25A) simultaneously

$$\Delta V_1 = 10.462 - 9.209 = 1.25 \text{ ft per sec}$$

$$\Delta p_1 = 47.415 \times 1.25 = 59.30 \text{ psi}$$

and from Eq (25A) the fluid velocity for the first interval is

$$V_1 = V - \Delta V_1 = 8.30 - 1.25 = 7.05 \text{ ft per sec}$$

The decrease ΔV_1 of 1.25 ft per sec, therefore, results in a pressure rise Δp_1 of 59.30 psi during the first interval, and the static pressure immediately upstream of valve increases to

$$p_1 = p + \Delta p_1 = 500 + 59.30 = 559.3 \text{ psi abs}$$

Second Interval:

$$\phi_2 = [1 - (2/5)]\,0.377 = 0.226$$

At the beginning of the second interval, the first pressure wave of amplitude +59.3 psi will have returned to the valve as a wave of subnormal pressure and will reduce the static pressure during the second interval by that amount. By Eqs (24) and (25)

$$\Delta p_2 = 47.415\,\Delta V_2 \qquad (24B)$$

$$V_2 = 8.30 - (1.25 + \Delta V_2) = 0.226 \times \sqrt{500 + (\Delta p_2 - 59.30) - 14.7} \qquad (25B)$$

Solving Eqs (24B) and (25B)

$$\Delta V_2 = 8.262 - 6.349 = 1.91 \text{ ft per sec}$$

$$\Delta p_2 = 47.415 \times 1.91 = 90.56 \text{ psi}$$

therefore

$$V_2 = V - (\Delta V_1 + \Delta V_2)$$

$$= 8.30 - (1.25 + 1.91) = 5.14 \text{ ft per sec}$$

and the static pressure immediately upstream of the valve becomes

$$p_2 = p + \Delta p_2 - \Delta p_1 = 500 + 90.56 - 59.30 = 531.26 \text{ psi abs}$$

In a similar manner, corresponding values can be computed for the third, fourth, and fifth intervals. The values thus obtained are plotted in Fig. 6. The maximum pressure being 559 psi abs during a closing time of 0.095 sec or 5 intervals. The pressure rise resulting from a valve closure of 0.095 sec is only 59 psi. In Example I, where the time of valve closure is 0.015 sec, the pressure rise is 393 psi.

The pressure rise for different times of valve closure are shown in Fig. 7 for the stainless steel pipe, Example I, with oil and water as mediums.

Values of the valve coefficient ϕ_n versus time of valve closure as used in the preceding example are given in Fig. 8. The curve can be constructed from Eq (32) after values of the orifice area A_n and the coefficient of discharge C_{Dn} have been determined for the specific valve. In Fig. 8 is also shown a typical curve for nonuniform valve closure.

COMPOUND PIPE LINE

In a compound pipe line consisting of several sections of different diameters as shown in Fig. 9, the equivalent fluid velocity and the effective velocity of the pressure wave can be determined as follows.

Where

$L_1, L_2, \ldots L_n$ = length of each section of pipe of constant dia, ft

$a_1, a_2, \ldots a_n$ = velocity of pressure wave in the respective pipe sections, ft per sec

a_E = effective velocity of the pressure wave, ft per sec

$V_1, V_2, \ldots V_n$ = velocity of fluid in the respective pipe sections, ft per sec

V_E = equivalent fluid velocity, ft per sec

G_n = rate of flow in respective section, U. S. gpm

D_n = inside diameter of respective pipe, in.

The fluid velocity in an individual pipe is

$$V_n = 0.4085\,G_n/D_n^2 \qquad (35)$$

and the equivalent fluid velocity V_E in the compound pipe line is

$$V_E = \frac{L_1V_1 + L_2V_2 + \ldots + L_nV_n}{L_1 + L_2 + \ldots + L_n} \qquad (36)$$

The effective velocity a_E of the pressure wave in the compound pipe line

$$a_E = \frac{L_1 + L_2 + \ldots L_n}{(L_1/a_1) + (L_2/a_2) + \ldots + (L_n/a_n)} \qquad (37)$$

EXAMPLE V. Assume that the pipes shown in Fig. 9 are stainless steel and the wall thickness t of each one is 0.049 in.; that the medium is water and the rate of flow is 40 U. S. gpm; and the lengths of the pipes are

$L_1 = 25$ ft; $L_2 = 15$ ft; $L_3 = 10$ ft

and that the inside diameters of the pipes are

$D_1 = 1.402$ in.; $D_2 = 1.152$ in.; $D_3 = 0.902$ in.

What is the equivalent fluid velocity, and what is the effective velocity of the pressure wave?

SOLUTION: For pipe I:

$$D_1/t_1 = 1.402/0.049 = 28.6$$

from Eq (35), the fluid velocity is

$$V_1 = 0.4085 \times 40/1.402^2 = 8.3 \text{ ft per sec}$$

for these values, Fig. 5 gives the velocity of the pressure wave in pipe I

$$a_1 = 4147 \text{ ft per sec}$$

For pipe II:

$$D_2/t_2 = 1.152/0.049 = 23.5$$

from Eq (35)

$$V_2 = 0.4085 \times 40/1.152^2 = 12.3 \text{ ft per sec}$$

and from Fig. 5

$$a_2 = 4234 \text{ ft per sec}$$

For pipe III: Using a similar procedure

$$V_3 = 20.1 \text{ ft per sec}$$

$$a_3 = 4326 \text{ ft per sec}$$

For the compound pipe line: from Eq (36), the equivalent fluid velocity is

$$V_E = \frac{25 \times 8.3 + 15 \times 12.3 + 10 \times 20.1}{25 + 15 + 10} = 11.9 \text{ ft per sec}$$

and from Eq (37), the effective velocity of the pressure wave is

$$a_E = \frac{25 + 15 + 10}{(25/4147) + (15/4234) + (10/4326)} = 4209 \text{ ft per sec}$$

PRESSURE SURGE SUPPRESSION

Pressure surges can be minimized by increasing the overall elasticity of the hydraulic system by installing a sealed pressurized air chamber (accumulator) in the hydraulic circuit as shown in Fig. 10. In such a circuit as the valve is closed, the kinetic energy of the flowing fluid is dissipated in compressing air in the suppressor. Thus, a gradual deceleration of the fluid takes place, regardless of the rapid closing of the valve, and pressure surges of small amplitude result.

Since the pressure wave originates immediately upstream of the valve, the surge suppressor to be most effective should be placed as close to the valve as possible on the upstream side.

For rapid valve closure, Eq (17) indicates that amplitude of pressure wave is of the same magnitude regardless of increase in the length of the pipe line, and depends only on the total change in velocity of the flowing fluid, and on the velocity of the pressure wave. When a pressure relief device such as a sealed air chamber is used, however, the length of the pipe line is of utmost significance because the total mass of fluid flowing in the pipe determines the kinetic energy that is to be dissipated in compressing the air in the surge suppressor.

Upon closing the valve the column

of fluid, because of its inertia, continues to flow into the sealed air chamber with diminishing velocity. The air is thus compressed, and the increase in pressure acts as a decelerating force upon the mass of flowing fluid. The device reduces surge pressure with time much like that resulting from gradual valve closure.

The action of the elastic air chamber results in a slow primary pressure oscillation.

Where

v_{Ap} = volume of air at pressure p, cu in.

v_{Apmax} = volume of air at maximum pressure p_{max}, cu in.

τ = period of oscillation of air cushion in a sealed chamber, sec

If both the pipe and the fluid are considered to be inelastic, the period τ of oscillation of the elastic air in the chamber is

$$\tau = 0.1512 \sqrt{\gamma L v_{Ap}/A\, p\, g} \qquad (38)$$

Fluid and pipe, however, are elastic and rapid secondary oscillations occur as previously discussed. With a surge suppressor in the system, the following mathematical approach gives results of sufficient accuracy.

Assume that the valve in Fig. 10 is closed rapidly and that the velocity of the fluid is decelerated from V ft per sec to zero in T sec. If the average velocity during the time of deceleration is taken approximately as $V/2$, then the volume of fluid entering the surge suppressor may be equated to the change in air volume, or

$$v_{Ap} - v_{Apmax} = 12\,(V/2)\,A\,T = 6\,V\,A\,T \qquad (39)$$

The following relationship between air volume and pressure also exists,

$$v_{Apmax} = v_{Ap}\,(p/p_{max})^{1/x} \qquad (40)$$

in which equation p_{max} is equal to

$$p_{max} = p + \Delta p$$

The value of x in the exponent is 1 for isothermal compression, and about 1.4 for adiabatic compression.

Substituting the value of v_{Apmax} as given by Eq (40) in Eq (39), the required air volume at the normal static pressure p is

$$v_{Ap} = \frac{6\,V\,A\,T}{1 - (p/p_{max})^{1/x}} \qquad (41)$$

When the value of T for a given pressure rise is obtained from Fig. 7, Eq (41) includes the effects of elasticity of pipe and fluid.

In the magazine *Nenth* (Water), Jan. 1939, W. L. Borendans gives the following approximate formula for the air volume assuming pipe and fluid inelastic, isothermal compression of the air, and rapid closure:

$$v_{Ap} = \frac{\gamma\,L\,A\,V^2}{24\,g\,p\,[(p/p_{max}) - 1 + \log_e (p_{max}/p)]} \qquad (42)$$

The results obtained when using Eqs (41) and (42) are of interest.

EXAMPLE VI. Assume that in Example I, an air chamber type surge suppressor, as shown in Fig. 10, is to be used to limit the pressure rise to 90 psi. Find required air volume?

SOLUTION: As given in Example I, the normal static pressure p is 500 psi abs, the velocity V of the fluid is 8.3 ft per sec, and the cross sectional area A of the pipe is 1.544 sq in.

From Fig. 7, 0.064 sec is time T required for valve closure, or time required for deceleration of the fluid, that results in a 90 psi pressure rise.

The maximum static pressure is

$$p_{max} = 500 + 90 = 590 \text{ psi abs}$$

Substituting in Eq (41) and assuming isothermal compression, where x equals 1, the required air volume is

$$v_{Ap} = \frac{6 \times 8.3 \times 1.544 \times 0.064}{1 - (500/590)} = 32.2 \text{ cu in.}$$

Assuming adiabatic compression, where x equals 1.4, the required air volume v_{Ap} is 44.1 cubic inches.

Using Borendans' equation, the required air volume v_{Ap} is 44.4 cu in.

CONCLUSIONS

The maximum amplitude of the pressure wave immediately upstream of a rapidly closed valve, that is, when T is equal to or less than $2L/a$, is directly proportional to the total change in fluid velocity and to the velocity of the pressure wave.

When the condition expressed by $T \leq 2L/a$ exists, the amplitude is not affected by a change in the length of the hydraulic line.

When the condition expressed by $T > 2L/a$ exists, the amplitude of the pressure wave increases with increasing line length.

The amplitude of the pressure wave may be reduced by: (1) Increasing the time of valve closure, thus increasing the number of pressure wave intervals; (2) increasing the pipe diameter, thus reducing the fluid velocity; and (3) decreasing the thickness of pipe wall and using pipe made of a material having a lower modulus of elasticity to reduce the velocity of the pressure wave; and (4) installing a surge suppressor in hydraulic circuit.

The air chamber type suppressor is the most efficient means of limiting the pressure surges to reasonable design values.

Any increase in the overall elasticity of the hydraulic line will reduce the amplitude of the pressure waves.

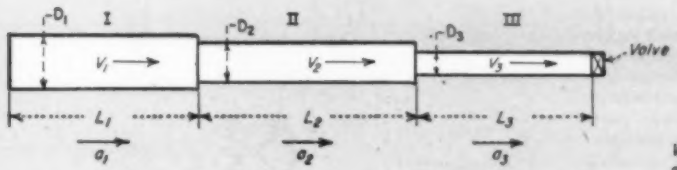


Fig. 9

Fig. 9—Compound pipe line that consists of three sections of different diameter.

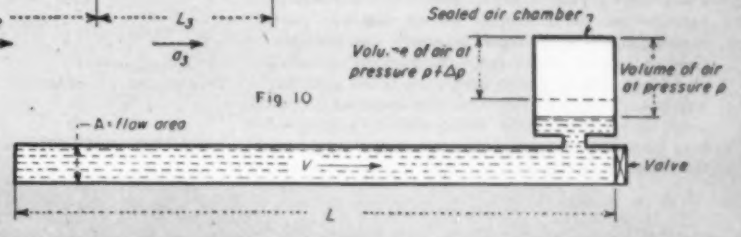


Fig. 10

Fig. 10—Sealed air chamber installed in pipe of hydraulic circuit to reduce amplitude of pressure surges.

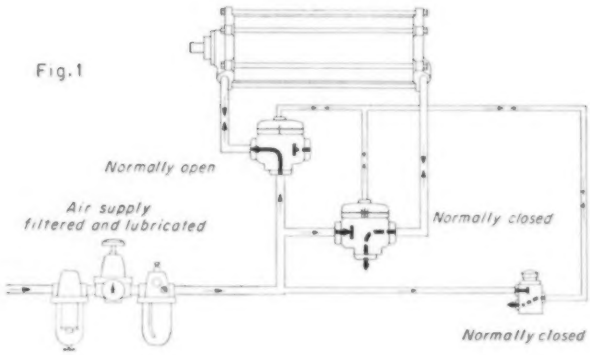
Remote Control of Double-

These six circuits were selected as practical examples of the choices a design engineer has with modern pilot-controlled, pressure-operated air control valves.

FRED W. HICKS
Chief Engineer—Valves, Hannifin Corporation

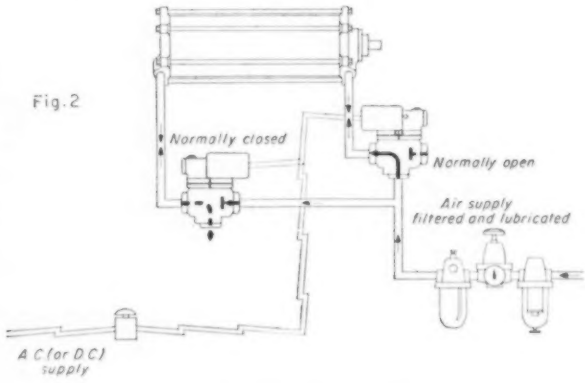
1. ALL PNEUMATIC CIRCUIT.—Two 3-way "master" valves are controlled by a single pilot valve. One of the master units is "Normally Closed"; the other "Normally Open" as shown in the diagram. For the conditions shown, the two 3-way valves are identical; only the pipe connections differ. Although a hand-operated pilot valve is shown, a foot-, cam-, or solenoid-operated unit could be substituted. The only electrical requirement for this circuit is that of the solenoid-actuated pilot. This is an advantage for installations involving hazardous atmospheres. Also, it is usually desirable to mount the two master valves as close as possible to the cylinder ports, but the pilot valve can be located at any convenient, remote point.

Fig. 1



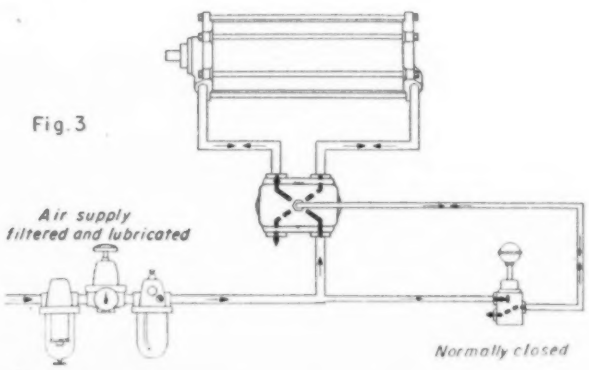
2. ALL ELECTRIC CIRCUIT—Two 3-way solenoid "pilot-master" valves. These have integral solenoid pilot heads, eliminating the separate pilot in the circuit above. Solenoids are connected in parallel in the electrical circuit, so the two valves will operate simultaneously. (Again, one valve operates "Normally Closed"; the other "Normally Open"; and the two valves are identical, simply being assembled and connected differently). Both this circuit and the circuit shown in Fig. 1 are fast acting because, with the two 3-way master valves mounted directly at the cylinder ports, it is possible to exhaust the air from in front of the piston rapidly. However, this all-electric circuit, is the faster of the two and is particularly well-suited to large, long-stroke cylinders.

Fig. 2



3. ALL PNEUMATIC CIRCUIT—One 4-way master valve is controlled by a 3-way pilot valve. Here the pilot valve shown is of the "hand toggle" type. If the cylinder is to advance and hold, as in a clamping application, a locking hand toggle valve might be used. Or this could be a foot-operated pilot valve, locking, non-locking. While the use of a 4-way master valve—rather than two 3-way master valves—leads to a simpler circuit diagram, good practice limits this circuit to small and medium-sized cylinders. On a large, long-stroke cylinder, two 3-way valves, one at each port of the cylinder, will operate the cylinder faster and conserve air, because they eliminate the filling and exhausting of long runs of large pipe between a 4-way valve and the pneumatic cylinder.

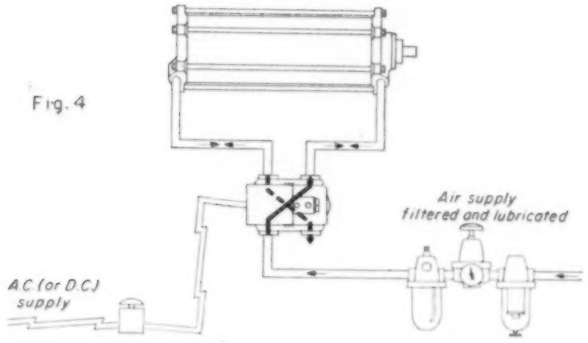
Fig. 3



Acting Pneumatic Cylinders

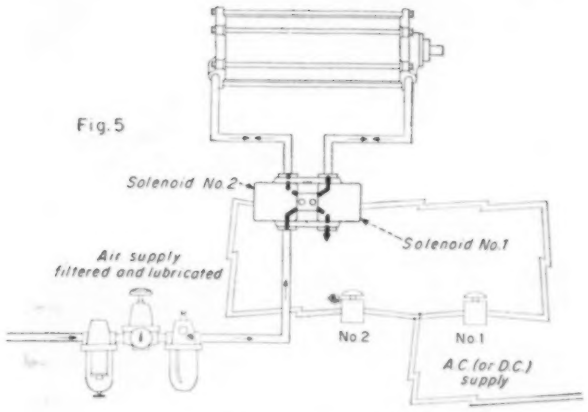
Each of the circuits shown provides simple, "advance-retract" operation of the cylinder, yet they form the basis for solving complex air control problems.

Fig. 4



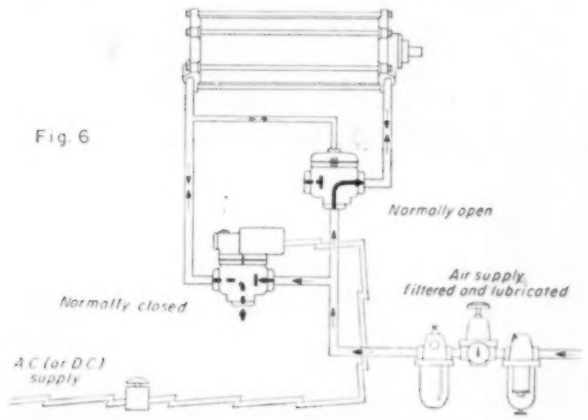
4. ALL ELECTRIC CIRCUIT—One 4-way solenoid pilot-master valve. This is a 4-way valve with the same type of integral pilot head used to actuate the 3-way pilot-master valves. This valve, too, operates almost instantaneously, and within the limitations mentioned under Fig. 4, it provides fast operation. With the particular design of 4-way valve shown, it is possible to reverse the action of the cylinder simply by using the left-hand port instead of the right-hand port as the inlet. This avoids criss-crossing the lines from the valve to the cylinder ports. In any of these electrically controlled circuits, cam-operated switches could have been substituted for the push button switches shown.

Fig. 5



5. MOMENTARY CONTACT CIRCUIT—One 4-way solenoid pilot-master valve, solenoid-controlled in both directions. The pilot valve in this integral pilot head is mounted between two solenoids. Momentarily energizing one solenoid causes the pilot valve to shift, and with it the main or master valve. Both valves remain shifted until the other solenoid is energized. Push buttons or limit switches need only be touched when this valve is used, and complicated electrical circuits are avoided. Also, with this type valve, there is no possibility of an accidental reversal of the cylinder resulting from electrical power failure, as there might be when a single-solenoid type valve is held in the actuated position by continually energizing its one solenoid.

Fig. 6



6. COMBINATION CIRCUIT—One "pilot-master" valve and one master valve. Here the solenoid-controlled pilot-master valve, operating "Normally Closed," acts both to admit air to the cylinder for the advance stroke and, at the same time, to actuate the "Normally Open" master valve so that it closes to pressure and opens to exhaust, thus permitting the piston to advance. While this is the most economical circuit for the electric control of double-acting cylinders, care must be taken in piping it to make sure that back pressure on the return stroke does not prevent the master valve from reversing. This will not ordinarily be a problem if the line to the head of the master valve is made large enough. If tubing is used, it should not be smaller than ¼ in., inside diameter.

Seven Methods for Solving

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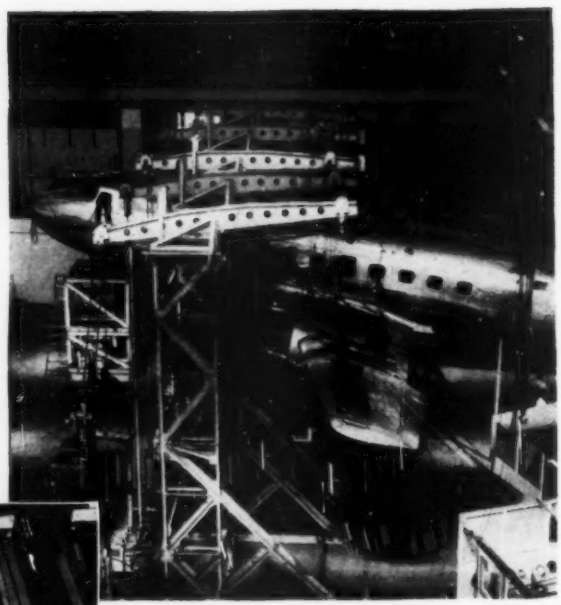
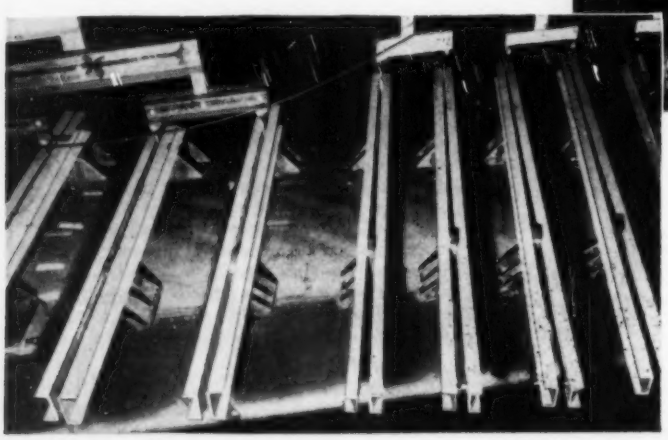
STRUCTURAL TESTING as practiced in the aircraft industry is often thought of as the simple loading of wings with sand bags to check their load-carrying capacity. This field of testing has been developed greatly in the few years since this interpretation was correct. As the loads on structural members increased, it became necessary to test load them with more dense materials, such as lead or cast iron, in order to avoid top-heavy and dangerous loads in the laboratory. But even this arrangement became too bulky, systems of hydraulic jack loading through linkages were developed.

Since World War II, the design of guided missiles has forced airframe manufacturers to pay special attention to structural testing. Some missiles are subjected to very high accelerations during launching, and consequently, means for duplicating such conditions in the laboratory have had to be devised. The facilities thus developed are of interest to designers of equipment carried within missiles, as well as to structural designers. This is because malfunctioning of electronic and hydraulic devices under impact conditions is as much of a problem as

1. HYDRAULIC JACK LOADING. This type of structural test permits checking the performance of an airplane wing as a whole, especially such critical details as the intersections of the wings and nacelles and operation of the ailerons while the wing is deflected. Usually, no attempt is made to simulate precisely the load distribution throughout the surface of the wing, because these details are studied in supplementary tests of smaller wing test sections.

The function of this test mechanism is to apply a series of concentrated loads to the spar caps so that the proper shear, bending moment, and torque can be developed at any point on the wing. Gussetted "T" section fittings are bolted to the spar caps as shown and coupled in pairs by double channel beams using a slotted connection at one end to avoid objectionable constraint. To each beam is applied a single concentrated load of magnitude





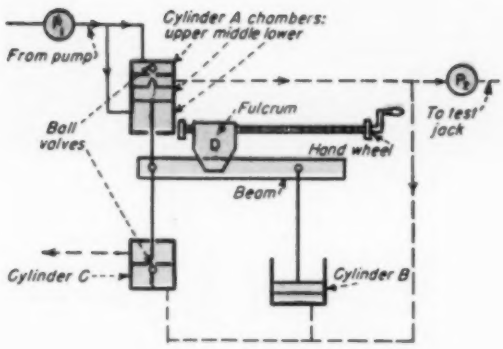
equal to the required increment of shear at that location. Loading points are inter-connected in groups by "whiffletree" systems, each of which is connected to one end of a walking beam. Other end of walking beam is attached to a hydraulic tension jack which applies the load. Distances from the walking beam fulcrums to their jack attachment points are selected so that all jacks can be operated at the same pressure.

Structural Test Problems

the design of the structure for the same conditions.

Another problem brought about by the missile program, and also by the development of very high speed piloted aircraft, is that of loading fins and other components at elevated temperatures. This is necessary because of the aerodynamic heating that occurs in a missile flying at high supersonic speed. The structural test problem in this case usually consists of setting up equipment that will: (1) Heat the structure to design temperature at a definite rate and with a certain required pattern of temperature gradient; (2) apply a properly distributed load to the structure at the right instant; and (3) obtain a record of time versus temperature, load and deflection up to and including the time of failure.

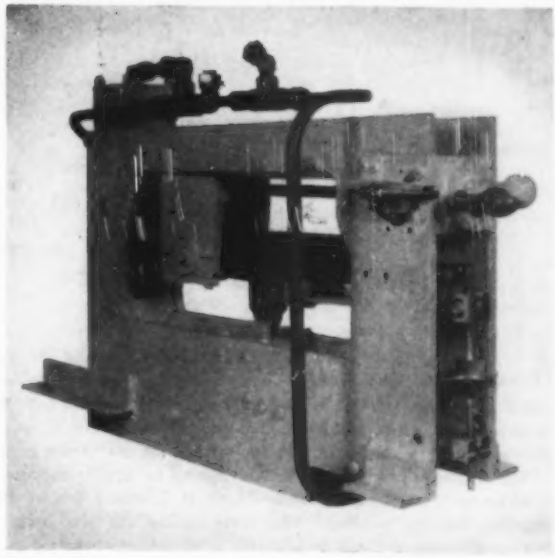
Usually the device used to solve this type of problem is improvised to fit the particular job. But since there is rarely another test of similar nature, the test equipment is usually scrapped after the test is completed. Thus, most of the equipment is designed as economically as possible, using welded steel construction and as little machine work as possible. There are, however, test devices that can be adapted to various test requirements, and they are used over and over again. The following studies include examples of both kinds of equipment.



2. HYDRAULIC PROPORTIONING VALVE. In a typical static structural test, loads are applied simultaneously to different points of the test structure by hydraulic jacks. Generally, each jack is required to be at a different load, but the loads must always be at the same ratio to each other as they are increased in increments from the zero starting point, until the structure fails. Sometimes this is accomplished by having a separate hydraulic pressure system for each jack which is controlled by a man operating an individual hydraulic pump and manual relief valve.

A more satisfactory method is to use hydraulic proportioning valves. Here, each pressure is controlled automatically by such a valve. Fluid from the hydraulic pump at pressure p_1 flows into the upper and lower chambers of cylinder *A*. The pressure acting on the bottom of the piston moves the latter upward until the projection on the top of the piston unseats the spring-loaded ball check valve. Fluid then bleeds into the middle chamber and from there into the bottoms of cylinders *B* and *C*, and to the test jack. When this pressure has reached the desired value, p_2, the force exerted by the piston in *B* moves the beam in a counter-clockwise direction about the fulcrum point *D*, which pulls down the piston in cylinder *A*, allowing the valve ball to reseat.

If pressure p_1 decreases, the beam becomes unbalanced and rotates counterclockwise about the fulcrum. This pushes the plunger down in cylinder *C*, unseating the ball valve, allowing fluid to bleed back to the reservoir until the system regains equilibrium. The hand wheel controls position of fulcrum, and hence ratio of p_1 to p_2.



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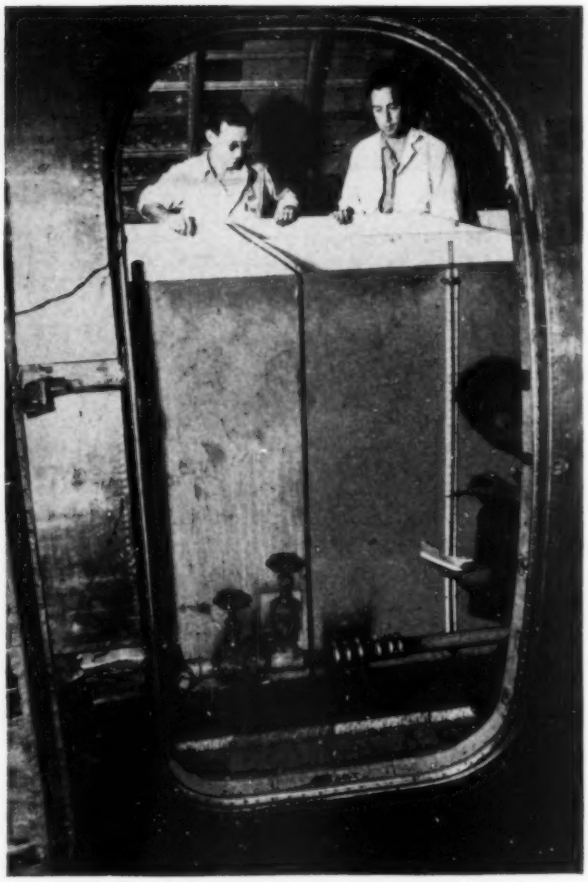
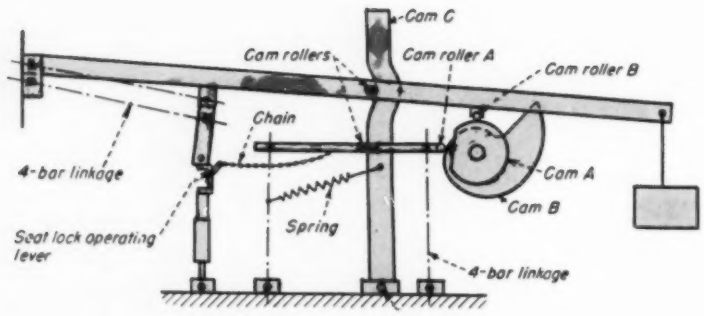
3. DEAD WEIGHT TEST. In a typical design condition for a transport airplane, the external upward acting wind load is counteracted by internal down loads representing inertia forces acting on passengers and cargo. In static testing to simulate these conditions, the time-honored method has been to distribute pig lead along the fuselage floor and cargo compartments. Instead of this, metal bands are sometimes attached to the outside of the fuselage skin and loaded tangentially from the outside. Although this newer method has many obvious advantages, it does position the load into the fuselage in a unrealistic manner, and it fails to give a test of the floor structure.

A compromise method that does simulate actual conditions utilizes water as the loading medium. Welded sheet iron tanks are arranged along the floor of the fuselage, one row on each side of the fuselage centerline. Each row is filled through a manifold that extends along the outboard side of the fuselage floor; and each tank has a gage glass and shut off valve.

When extremely high unit loading has to be simulated as is sometimes necessary in large fuselages like the DC-6, the tanks can be designed in sections. Each section will then easily pass through the main doorway. Once within the fuselage, the various sections are welded together at their respective locations.





4. MECHANISM WEAR TEST. Passenger seats in the DC-6 series airliners incorporate a mechanism that allows the passenger to incline his seat backward at any desired angle within design limits and to lock it there. This lock mechanism is also designed so that the seat back can be pushed easily into the forward position, overriding the lock, when the seat is not occupied.

The test equipment shown is designed to apply, repeatedly, the loads and motions to a seat lock mechanism such as it would receive in service. The test assumes that the passenger first leans against the seat back, presses the release button allowing the seat back to tilt to a position near the end of its travel, and then releases the button which engages the brake mechanism. At the end of the flight, the unoccupied seat is pushed to the upward position without being unlocked.

The load beam in the test rig at left is shown in the dropped position. Cam *C* has lifted the roller from cam *A* and, in so doing, slackened the chain and engaged the seat lock.

The testing machine is driven by a 12-rpm output geared electric motor that rotates two cams. The sequence of operation is as follows: With the loading beam in the up position (corresponding to the forward position of the seat back), cam *A* releases the seat lock allowing the beam to drop until cam *C* engages the seat lock which stops the loading beam at a point representing the seat's reclined position. Cam *C* is controlled by the loading beam, rather than by the rotating shaft, because variation of the friction of the seat lock causes a change in the timing of the drop of the loading beam. The final part of the cycle consists of lifting the loading beam by means of cam *B*, while the brake is held by cam *A* in the engaged position, allowing it to drag as originally assumed.

This method of testing is typical of many rigs especially designed for checking wear in high-durability mechanisms.

5. DROP TESTING TECHNIQUES. Landing gears are frequently drop tested by attaching them to the bottom of a steel cart that slides down a vertical track. After the cart is lifted a required distance and the wheel rotated at a speed corresponding to the landing speed of the airplane, the cart is allowed to fall. The shock absorber and tire absorb the energy of impact.

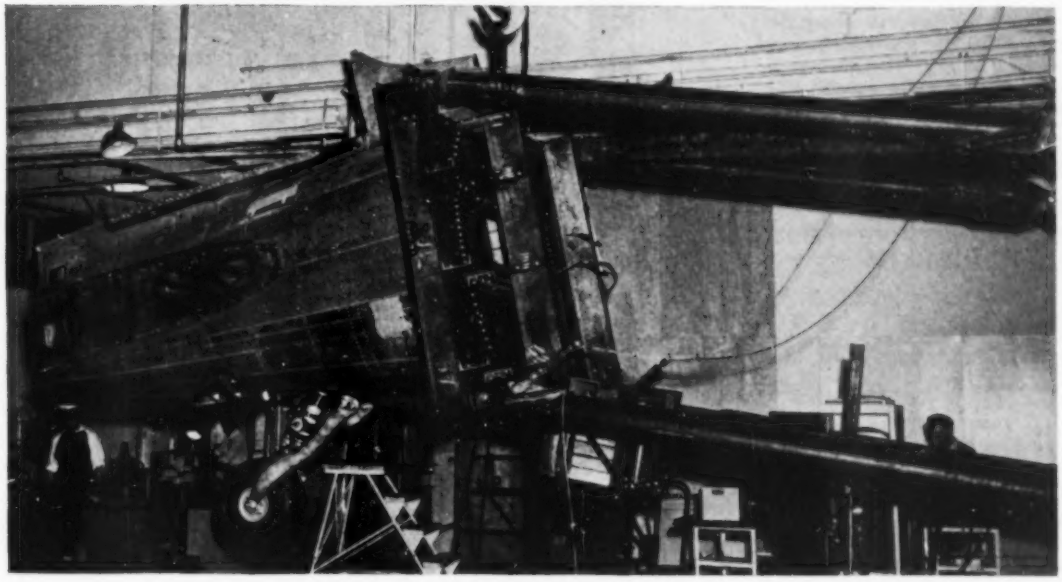
A more true-to-life condition is obtained by dropping a complete airplane. The deflections of the airframe act as part of the regular shock absorbing system, affecting the loads in the landing gear shock absorber. Furthermore, drop testing the complete airplane is a strength test of the airplane structure itself.

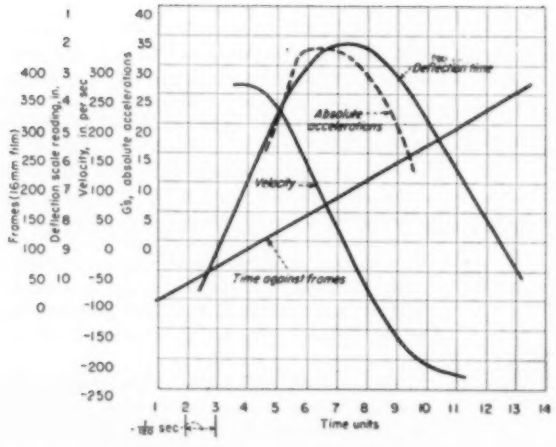
The example illustrated below is a compromise in that only the structure in the region of the landing gear is included in the test. The empennage and landing gear are guided so that they move in a vertical plane without rotation. This is done with the four-bar linkage connecting the test section to the fixed test structure.

In the down position, the tire rests on a "reaction platform," which contains an electric strain gage load measuring device. The signal from this load pick-up is transmitted to an oscillograph so that during the impact there will be a record of the wheel reaction at any instant. The oscillograph also receives signals from slide wire position indicators that measure the height of the landing gear, relative to the ground, and the travel of the shock absorber cylinder. At the same time, dynamic measurements of oil and air pressures in the shock strut, and strain gage measurements at critical locations in the structure are recorded.

It is sometimes necessary to measure high acceleration transient impulses that are difficult to obtain with the best of accelerometers. A typical example is a drop test in which the maximum acceleration is 35g and the duration about 1/50 of a second. The mass is dropped along vertical tracks through a distance of approximately 100 in. onto a preloaded air cylinder.

The first step in obtaining acceleration by this method





is to determine the travel of the moving body vs. time during the motion. An inch scale parallel to the direction of the motion is attached to the mass before it is set in motion. A pointer is fastened to a stationary object so that the inch scale will pass close to it during the motion to be studied, and both will be within the field of view of a high speed movie camera during the action. Knowing the speed of the camera (in this case, a Fastax, 3,500 frames per sec), it is relatively simple to plot from the record on the motion picture film, a curve of space vs. time. Slopes of the space-time curve are measured graphically and plotted (at left), resulting in a curve of velocity vs. time. In the same way, the slopes of the velocity-time curve are measured and plotted, yielding the desired curve of acceleration vs. time—the second differential of space with respect to time.

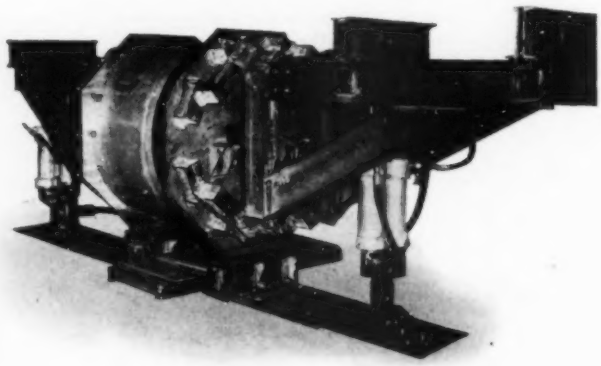
(continued on next page)

6. BENDING TEST ON CLOSED SECTIONS. Frequently it is necessary to determine the bending strength of monocoque and semi-monocoque structures such as cylinders or wing box sections. One of the important problems is to introduce the bending moment into the ends of the test section so that the bending stress of any element in the structure is directly proportional to the distance of the element from the neutral axis of the structure. Stated algebraically, the stress at any point in the test structure must satisfy the fundamental equation f_B equals MC/I where f_B is the bending stress, M is the bending moment, C is the distance to the neutral axis, and I is the moment of inertia of the section.

In the case illustrated, the test section is a simple sheet metal cylinder about 40 in. in diameter. The cylinder is attached at each end to a steel plate by a circular metal attach angle. The plate is supported on a set of rollers which will insure that when the test loads are applied, only vertical reactions will occur at this point without any undesired horizontal or rotational restraint. Both M and I are constant throughout the length of the test section. The distances between the pivot point at the base of each plate and its respective outboard loading point should be equal. Thus with equal jack pressures, the moment will uniform throughout the test section.

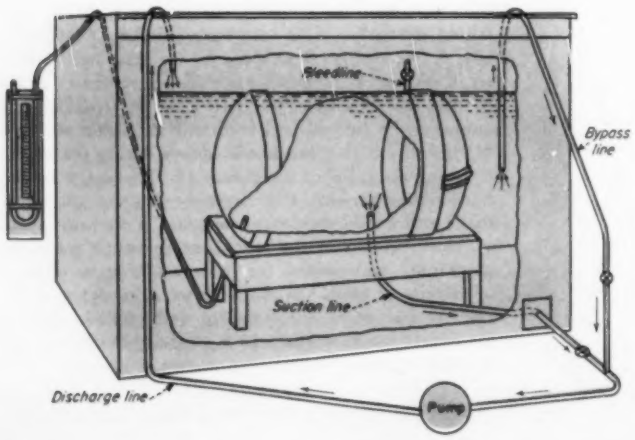
To carry the desired loads into the cylinder, sixteen equally spaced loading points are laid out on each end plate in line with the curved wall of the cylinder. A concentrated load is applied to each of the points on the end plates, with each load being proportional to its distance from the neutral axis. This is accomplished with a system of beams stacked as shown around the loading points, and combined with triangular loading trusses to which the hydraulic loading jacks are attached. To carry the vertical shear load from each triangular truss to the end plate, there are mating brackets attached to the plate and truss. These prevent the system of beams from rolling.

Strain gage measurements have demonstrated that this rolling system does distribute the load into the test structure in the manner intended. Though the cost of fabricating the test structure just described is appreciable, the accuracy obtainable in load distribution justifies the time and money.



7. VACUUM TEST OF PRESSURE VESSELS. The advantage of conducting pressure tests of enclosed vessels using a fluid rather than air as the pressurizing medium is that the fluid, being relatively incompressible, does not store much energy when pressurized. The danger to nearby personnel when the pressure vessel fails, is therefore lessened, as compared to a similar test using air pressure.

It is possible to enjoy the same advantage in testing for negative pressure by submerging the test structure in water and pumping the water from the test vessel back into the surrounding water. A further advantage is that the pump can be a simple, available type and will continue to operate efficiently at low pressures because the density of the water remains constant.



In the test illustrated, the vessel was designed to carry external pressure load. As a fair amount of leakage was expected, the vessel was sprayed with a material normally used to form a protective cocoon around a part stored in an exposed area. This was effective as a seal although some breaks occurred in the cocoon when the vessel deflected. Referring to the diagram, the test vessel was placed in the tank of water, filled completely and the bleed line valve closed. The suction line valve, and by-pass line valve were opened and the pump was started. Pressure in the vessel was controlled by manipulating the latter valves and measured with a mercury manometer.

The mode of failure of the vessel was of unusual interest. The surface of the cylinder first developed a pattern consisting of system of waves between each pair of internal circular stiffeners. Each system of waves was 90 deg out of phase with the system on either side of it. As the pressure was decreased, the waves deepened, until the cylinder collapsed under the pressure acting on one of the domed ends.

The economy and safety that accompany the use of a liquid pressure medium are highly desirable in a variety of specialized applications.

BRITONS CAN HAVE PROSPERITY —If They Want It

What is required to get Britain, our key ally in the grand alliance of the free world, firmly back on her economic feet? The purpose of this message is to throw light on this crucial problem, which afflicts our other European allies also.

At the moment, Britain is enjoying a respite from the economic crises (of 1947, 1949 and 1951-52) which have plagued her postwar course. This respite may well continue for some time. But almost no one whose judgment is trustworthy believes that Britain has acquired sufficient economic strength to safeguard her against further economic crises in the years immediately ahead.

Two British Views

New and clear light on what should be done to that end has recently been shed by two noteworthy British publications. One is a book, "We Too Can Prosper," by Graham Hutton, distinguished British economic writer and administrator. The other is an article, "The Riddle of Prosperity," published by THE (London) ECONOMIST, Europe's most eminent economic journal.

Combined, these two publications present in sharp relief the basic problem that must be handled successfully if Britain is to be safely solvent. As is implied by its title, ***the Hutton book demonstrates that Britain can be made prosperous by readily feasible procedures, patterned on what has been done in the United States, to increase its industrial efficiency. But, says THE ECONOMIST, with Mr. Hutton's book in mind, this is not the most basic problem, which is, "How shall we make the British people determined to be prosperous?"*** This is a problem of incentive or motivation.

Compared with that of the United States, average industrial efficiency in Britain, as in most of Western Europe, is low. In his book Mr. Hutton remarks that "fifty years ago an American industrial worker turned out roughly the same amount in a day as his opposite number in Britain, Germany or France. . . . Today, he turns out from two to five times as much."

In large part it is this lag in output per hour or "productivity," as the technicians call it, which makes Britain and other key countries in Western Europe a continuing prey to economic crises. Moreover, the great disparity in productivity between the U.S.A. and most

of Western Europe is a major barrier to knitting the free world into a smoothly working economic whole. As one observer put it, "when the American economy catches a cold, the European economy gets pneumonia." This is largely because Europe is so much weaker in productive strength.

No Shortage of Knowledge

Yet the knowledge which would enable the countries of Western Europe, and particularly Britain, to increase their industrial productivity has been mobilized and is readily available to them. It is with this process for Britain that Mr. Hutton's book is concerned. In the book he summarizes the findings and conclusions, virtually all of them unanimous, of 66 teams, composed of British industrial managers, technicians, shop workers and labor leaders. Over a period of three years these teams completed a comprehensive series of inspection and study trips in the United States under the sponsorship of the Anglo-American Council on Productivity. The product of that effort, he remarks, is "a set of documents the like of which, on such a scale and of such practical value, has never been seen in the history of international and cultural borrowing."

Psychology the Key

From study of these documents, Mr. Hutton concludes that better capital equipment is the key technical ingredient of higher industrial productivity in Britain, and constitutes "the most urgent . . . need of British industry." But he finds that ***even without new capital equipment a "15% rise in productivity can still be achieved by reorganization of work," and that such an increase would "solve Britain's chief social and economic problems."***

Then why is not such an increase in productivity, demonstrated by the Anglo-American productivity teams to be so clearly within technical grasp, promptly forthcoming? Mr. Hutton, quoting one of the team reports, remarks that, ***"'the greatest obstacles to increased productivity are psychological rather than technical.'*** We have to deal first and foremost with men, not machines." And THE ECONOMIST, pursuing the line of inquiry suggested, reaches the conclusion that, by and large, the people of Britain do not want to prosper by being more efficient. THE ECONOMIST says:

> "The real secret of American productivity is that American society is imbued through and through with the desirability, the rightness, the morality of production. . . . But in Britain, if any moral feeling at all survives about economic matters, it is usually a vague suspicion that economic success is reprehensible and unworthy. From this difference in attitudes everything else follows."

"How," asks THE ECONOMIST, "shall we set about restoring some belief in the rightness of effort, the morality of success?" For this question it has no ready answer. Neither have we. We are confident that the British people will neither be cajoled nor coerced into trying to match our productivity. Basically the problem seems to be to demonstrate clearly to them the truth of the proposition, set down by Graham Hutton, that "there is no goal, aim or end before a Good Society which the raising of that society's material productivity cannot render easier of achievement." Doing that in an old and settled country like Britain is obviously an extremely formidable undertaking. But ***until it is done, the crucial job of getting Britain and the rest of Western Europe firmly on its economic feet will remain to torment all of us.***

McGraw-Hill Publishing Company, Inc.

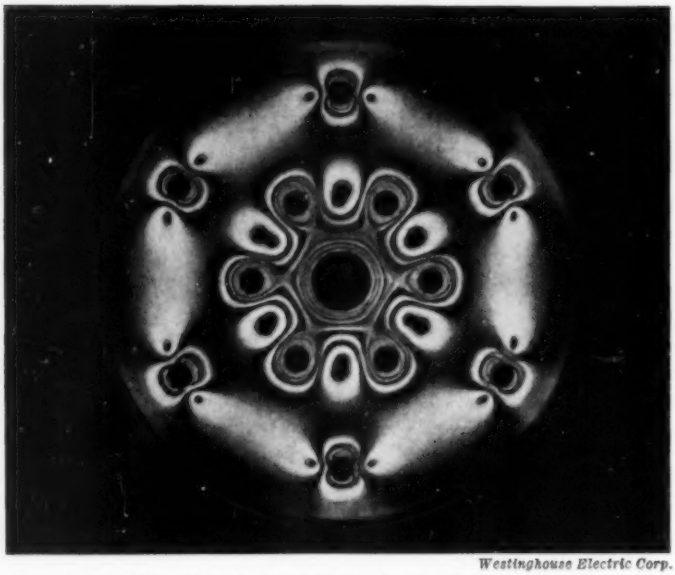
Wire mesh plot is basis for checking velocity pattern of gas passing between blades in turbine cascade.

MODELS IN DESIGN

INDUSTRY has long used models of one kind or another to assist in the design, improvement and marketing of products. But their importance has seldom been so evident as the present when industrial and consumer products are becoming more complex, performance standards are being set higher, and styling is being depended upon to make a product stand out above competition.

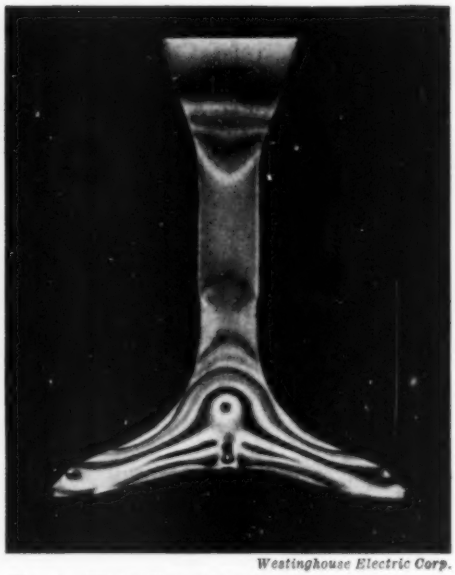
The net result of this trend is to raise appreciably the cost of every phase in a product development program. Major errors in designing and styling a product must therefore be uncovered at or soon after the time they occur, else subsequent discovery makes the cost of corrections prohibitive.

Because they are relatively inexpensive, in many cases easy to make, and a direct source of accurate design data, models are being assigned a role of primary importance in product design. A familiar example is the omni-present automobile. When envisaging the car of the future, say for 1960, when there might well be a rear-engine drive, manufacturers use detailed scale models to find out how the



Westinghouse Electric Corp.

Fig. 1—Two-dimensional photoelastic stress study of Bakelite disk with a series of holes arranged symmetrically. Figures show stress patterns around holes as disk is rotated in polarized light.



Westinghouse Electric Corp.

Fig. 2—Three-dimensional stress study of poppet valve illustrates "freezing and slicing" method for preserving fringes.

rear-mounted engine will change space requirements for passengers and the overall proportions of the body. Or take the 1955 car that may have a new engine. Stress models of the crankshaft would be studied, and mock-ups of a dummy engine made to check for alignment of controls and interferences with adjacent objects. Or consider next year's modification of this year's body design. Changes of trim, grille and small hardware would be tried and an exact or true appearance model assembled. Final decisions as to the new "look" and "feel" of the car would then be made before change notices are issued and parts ordered.

These are just a few of the uses for models as they apply to the automotive field. However, their pattern of usage differs widely from product to product so that a simple breakdown into two basic model types is desirable. These are (1) models for making dimensional similitude studies and (2) models for checking various phases in developmental studies.

MODELS FOR DIMENSIONAL SIMILITUDE STUDIES

A model is a device so related to a physical system that data taken from it can be used to predict accurately the performance of the system in the desired respect. The physical system for which the predictions are to be made is called the *prototype*.

In general, more than one type of model may be used in predicting the behavior of a given prototype. One type may be similar in appearance to the prototype; another, from which just as accurate predictions can be made, may bear no resemblance to the prototype. By the same token, several characteristics of the prototype may be predicted from one particular model, while only one characteristic is predictable from another model.

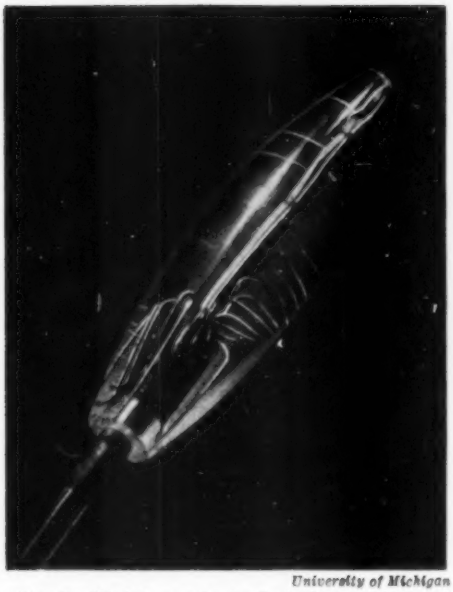
Types of Models. Four general types of model are useful in predicting the behavior of the prototype. These are classified as *true*, *adequate*, *distorted* and *dissimilar*. True models have all the significant characteristics of the prototype faithfully reproduced to scale. In addition to being geometrically similar to the prototype, the true model satisfies all other restrictions introduced by design conditions. It can be used for predicting characteristics in relation to different design parameters.

Adequate models are those from which accurate predictions of one characteristic of the prototype can be made, but which will not necessarily yield accurate predictions of other characteristics.

A distorted model has some design condition that is violated. Under certain conditions, particularly where flow of fluids is involved, it is impracticable, if not impossible, to satisfy all of the design conditions with a length scale other than unity. Lack of suitable materials or inavailability of specified dimensions may lead to the adoption of two or, in many cases, several different length scales.

Dissimilar models bear no apparent resemblance to the prototype, but through suitable analogies they give accurate predictions for behavior of the prototype. For example, information concerning the torsional stresses in a shaft can be obtained from measurements taken on a soap film, or the characteristics of a vibrating mechanical system can be duplicated in an electrical circuit.

Scales. A length scale is the ratio of a pertinent distance on the prototype to the corresponding distance on the model. For a true model, the



University of Michigan

Fig. 3—Miniature of missile body used in wind tunnel to measure pressures acting at Mach 4.0. Unit is 9 in. long and 2 in. in diameter.

Allis-Chalmers Mfg. Company

Fig. 4—Test flume for determining flow characteristics of centrifugal pump intake structure is one sixth actual size. Lucite window facilitates photographing flow patterns for detailed study.

selection of the distance is immaterial, since all distances on the model are $1/n$ times the corresponding distance on the protoype. However, a distorted model may have more than one length scale. Other scales, which are generally derived from the length scale and the design conditions or from an applicable law like $F = ma$, are based on quantities such as force, mass, area, volume, velocity and acceleration.

Scale Effect. This term has unfortunately carried the implication that an "answer factor" of some kind is required in model analysis because scale models just do not behave the same way as full-scale prototypes. This implication is misleading, for a model will always give accurate predictions without any scale effect if the model is a true model. Investigation of those situations in which scale effects are reported always reveal that the so-called "answer factors" are simply prediction factors resulting from the use of a distorted instead of a true model.

In practical model design and analysis, it is often necessary to use a distorted model with the full knowledge that it does not meet the requirements of a true model, and prediction factors must be evaluated either algebraically or experimentally. However, these factors are in no sense required simply because the model is different size from the prototype—they are required because the model is distorted.

The following studies illustrate different types of models and how they are used to supply design data in connection with basic research and development in the industrial, governmental and consumer product fields.

Photoelastic Stress Models. This method of determining the stresses and their distribution in metal parts under actual service loading often enables better and more economical designs. The models are true reproductions of the prototype and therefore supply accurate data directly.

There are two principal photoelastic techniques. In the two-dimensional method, models are cut from flat sheets of special materials. When these models are loaded in a manner similar to the prototype and examined in polarized light, optical retardation or interference effects are observed which can be related to the state of stress. When using monochromatic polarized light, a configuration of light and dark bands, known as fringes, appears in the model, as shown in Fig. 1. This configuration of fringes is referred to as a stress pattern, and is generally unique for every shape of model and type of loading.

By the simple process of counting fringes and multiplying by a calibration constant, known as the fringe value, the stresses can be obtained throughout the model.

While there are, actually, very few practical problems involving truly two-dimensionally stressed members, a great number of structural and machine parts can be simulated by flat models with loads acting in the plane of the model.

Two-dimensional photoelasticity has been used for a great variety of stress analysis problems including:

(1) The determination of localized stresses for regular geometric shapes or discontinuities. The maximum stress at the discontinuity (filter, hole, groove, etc.) is determined and divided by a convenient nominal stress, to give a ratio known as the "factor of stress concentration." This factor is applicable in full to brittle materials, and in full or part to materials subject to fatigue.

(2) The determination of stresses in specific machine parts, such as

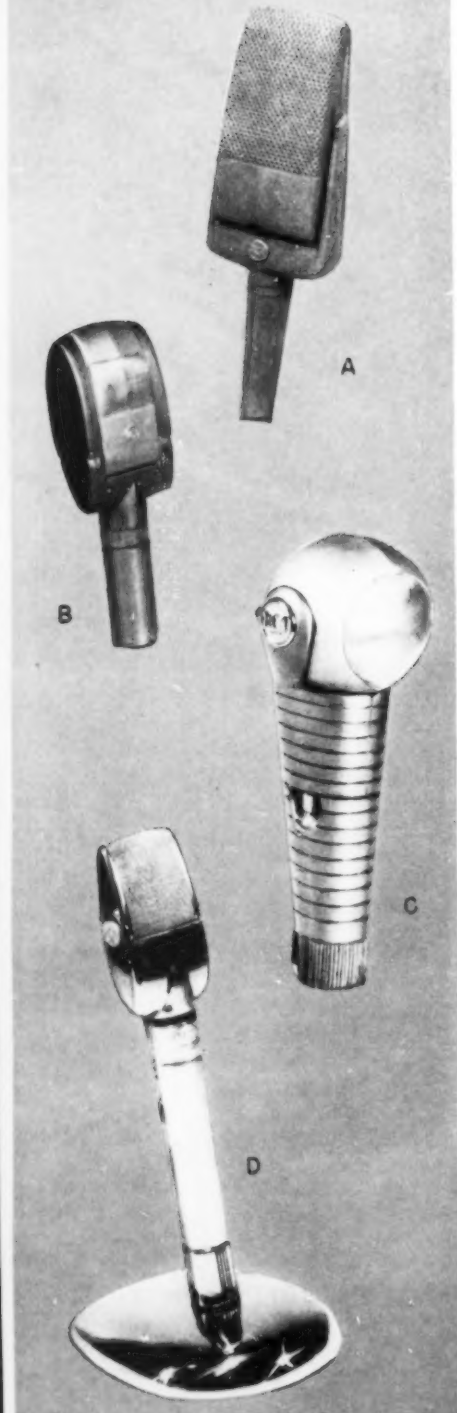


Fig. 6—Preproduction models show early stages in development of microphone. First rendition (A) is modeling clay on metal armature mounted in wooden pedestal. Wooden model (B) with metal screen is refinement of basic shape, including movable head. Alternate design (C) permits comparison of heads and incorporation of cable disconnect. Working model (D) is basis for production tooling and for check of assembly methods.

Radio Corporation of America

spur gears, turbine blade roots, railway car wheels, rails, curved links, rollers, and miscellaneous automobile parts.

(3) The analysis of stresses in statically indeterminate structures.

(4) Stresses in dams and earthworks where body forces can be simulated by using gelatin models.

(5) Study of transient stresses using high-speed photography.

(6) The study of fluid flow using the photoelastic effect developed in certain liquids by the viscous shear.

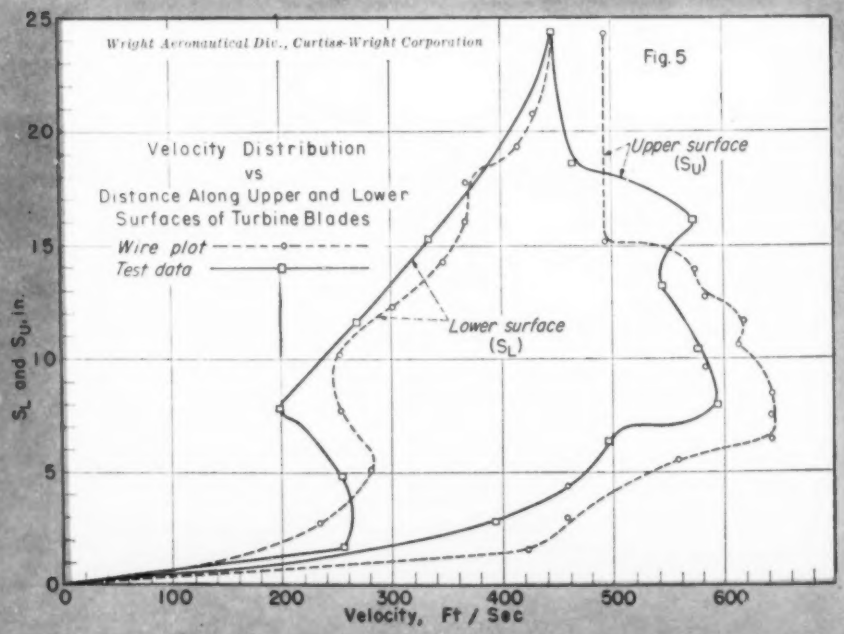
Recently, photoelasticity has been extended to three-dimensional analysis chiefly by the method of "stress freezing" and slicing. Essentially, this method consists of preparing a three-dimensional model and loading it in a manner similar to that of the prototype. The temperature is then raised to a certain value, known as the critical temperature, and slowly lowered to room temperature with the loads acting. The loads are then removed leaving a system of strains fixed in the model. It has been shown that these fixed or frozen strains represent an elastic state of stress. The model is then cut into slices without disturbing the fixed strains, and the stresses determined in the slices, as in two-dimensional photoelasticity.

The freezing and slicing method is particularly suited for the study of stresses in models containing sections of symmetry, such as the poppet valve model shown in Fig. 2. This is a stress pattern in the central longitudinal slice of the valve model from which the major principal stresses can be obtained.

Research Pressure Models. The model shown in Fig. 3 represents a typical V-2 type missile body. It is used in the 8 by 13 in. supersonic wind tunnel at the University of Michigan to measure pressures acting on it at Mach 1.5, 2.0 and 4.0. From this test data, the performance of a full-scale missile can be predicted to a reasonable degree of accuracy, yet at a fraction of the cost of the missile itself.

Fluid Flow Models. Exact analysis of many fluid flow problems is virtually impossible because of the complex paths followed by the individual elements of the fluid. Analytical solutions have been developed for certain conditions by utilizing simplifying assumptions, and empirical formulas are available for many of the common problems. In other applications, models are relied upon for giving the needed information as, for example, in the design of such complex structures as ships and aircraft.

The design of centrifugal pump intake structures is largely determined through the use of model tests conducted in a test flume, Fig. 4, at the Allis-Chalmers pump research laboratory. The 12 by 3½ by 3-ft flume, which is made of sheet steel and Lucite, serves as a



water-tight enclosure for temporary plating and plywood that form the particular intake passages being tested.

The model pumps used for all tests are 7 by 5 in. axial-flow units rated at 730 gpm, 11-ft head, three hp at 3,550 rpm. Complete pump characteristics of head, capacity and power are measured. All size dimensions are scaled down to the same proportion with a reduction proportion factor of one to six on a direct ratio. A 14 in. circulating pump and external piping loop produces flow through the tank to simulate pump settings in high-velocity tunnels.

Observation windows in the sides of the tank, Fig. 4, permit still and motion picture photography. Small rubber pellets are sometimes put in the stream to make the flow patterns more visible. Various phenomena are easily demonstrated through use of these pump models and many types of individual power station conditions can be simulated for observation and study.

Dissimilar Models. As stated, this class of models bears little or no resemblance to the prototype. The best examples are the various analog and digital electronic computers, which are currently being applied to simulate some of the complex physical systems encountered in product design.

One of the less familiar techniques now being used in connection with gas turbine blade design centers around a wire mesh plotting device. Data obtained from it is compared with "live" test data to determine the turning angle and velocity distribution for a blade cascade.

The plot as shown on the first page of this article is for two-dimensional incompressible flow through two passages in a cascade. Since any flow field can be represented as an orthogonal network of stream and equipotential lines, a suitable mechanical device will describe the gas flow relationship.

The stream and equipotential lives are represented by steel wires strung through pins at right angles to each other. For incompressible flow, these lines must form curvilinear squares, a condition that is satisfied if the diagonals of the squares meet at right angles. Thus, another network of wires placed at an angle of 45 deg with respect to the first network, and passing through another set of holes in the same pins serves as diagonals.

The graph in Fig. 5 shows velocity distributions from test and plot data, for which the two curves have the same general contours. This represents good agreement, when it is considered that compressibility is not taken into account. A modification of this technique involving special plastic templates that allow for compressibility is currently under investigation.

MODELS FOR DEVELOPMENTAL STUDIES

Preproduction Models. The evolution of a microphone is typical of many small products that must "look and feel right" to insure success when marketed. Models of such products can be full size, thereby giving an entirely realistic conception of appearance and operation, and, at the same time, keeping low the cost and time for construction.

Once management has decided to produce a new design, a rough mock-up is improvised "to have something to start with." It can be made in the most convenient manner from available materials. The model in Fig. 6(A) is constucted of modeling clay supported by a metal armature that allows slight tilting of the upper assembly. The pedestal is wood and the trade-mark a standard part.

A precision mock-up is the next step in formulating the features of the microphone. Fig. 6(B) shows such a model made principally of wood. A perforated metal screen is

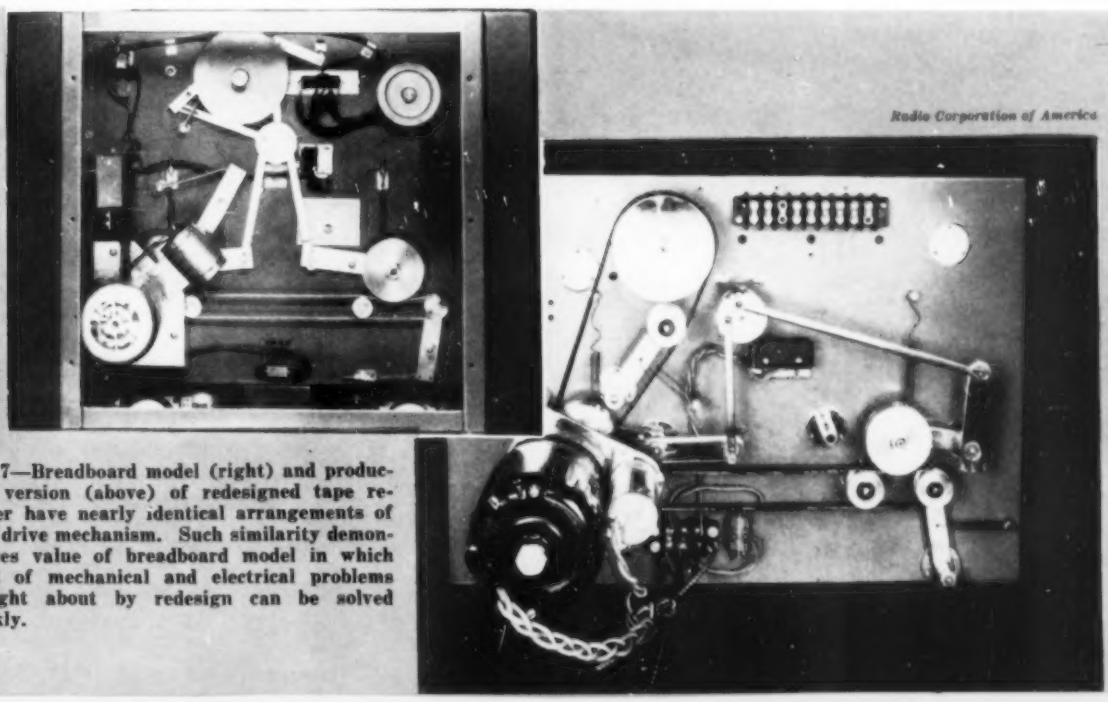


Fig. 7—Breadboard model (right) and production version (above) of redesigned tape recorder have nearly identical arrangements of tape drive mechanism. Such similarity demonstrates value of breadboard model in which most of mechanical and electrical problems brought about by redesign can be solved quickly.

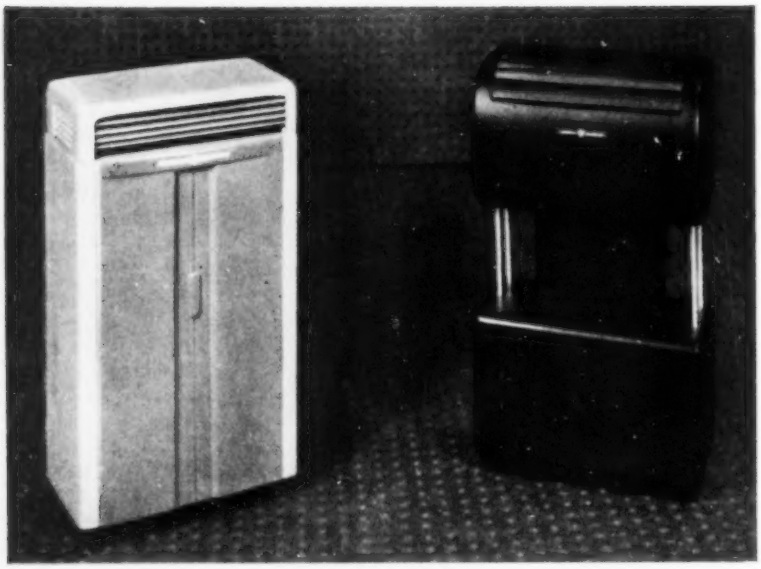
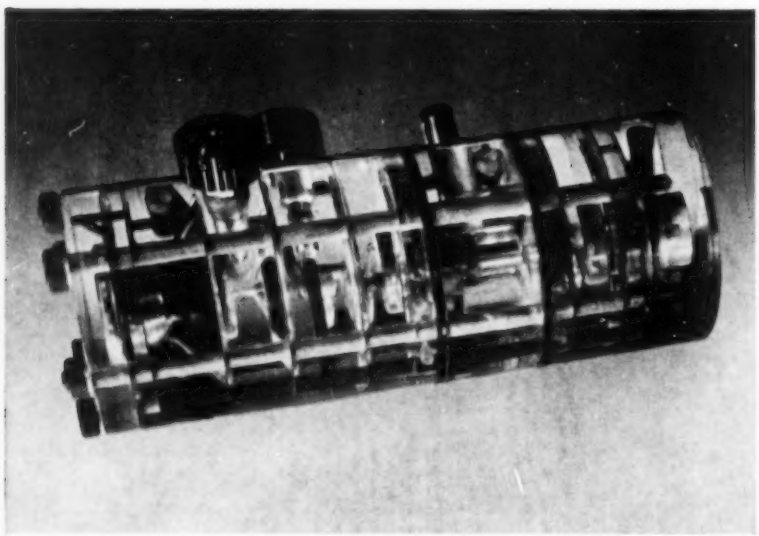


Fig. 8—Full-color appearance models of two designs for home air conditioner permit true evaluation of contours and color by all concerned with product's development and marketing. Conformance with prevailing tastes in home decoration color schemes and styles can thus be checked and evaluated.

attached as shown and all other surfaces are treated such that a metallic finish is simulated. Provision is again made to permit tilting the upper section.

A second wood mock-up model is shown in Fig. 6 (C) with the head free to rotate in the collar-like yoke. This unit permitted comparing the appearance of two distinctly different head designs. An added feature of this model was the incorporation of a cable disconnect plug in the shaft. The mechanical problems of mounting the plug, as well as its effect on the overall appearance could thus be studied.

Although the design in Fig. 6(C) was never used due to certain aspects of its shape, the data obtained in connection with the disconnect plug were put to use as is evidenced by the recess in the shaft of Fig. 6(D). This assembly is one of several preproduction working models upon which the tooling for some parts was based.



Breadboard Models. In the development of assembly products composed of many interrelated parts, designers often depend upon breadboard models to "ferret out" mechanical and electrical "bugs."

This type of model can be of the formal Erector-set variety when there is frequent demand for a given set of related components. Or, as is more general practice, it is a matter of assembling make-shift parts and materials when building up such models.

The redesign of a commercial tape recorded illustrates the great value of a breadboard model. Purpose of the redesign was to simplify the film spool drives by substituting a single electric motor for individual drive motors used in earlier models. The most practical method of finding out whether the centralized drive was workable was to

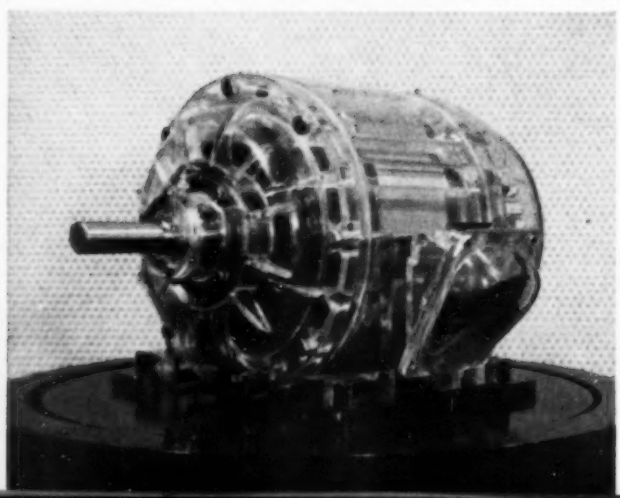


Fig. 9—Demonstrator models of electric motor and pneumatic controller typify growing use of "peek-a-boo" assemblies. Transparency of controller simplifies job of explaining movement of air through complex network of passages. Brown Instrument engineers use this model, as General Electric personnel do the motor model, both within the company organization and with outside groups.

mount a metal panel on a wooden frame, Fig. 7 (right), and attach various parts to each side.

Many of the necessary parts were already available, while some of those needed in the new drive were made up for this specific model study. During their assembly considerable attention was given to details in the arrangement of both the mechanical and electrical systems. Though this "arrangement factor" was not a "must" as far as operational checking of the centralized drive was concerned, the time and effort expended was well spent. This is demonstrated by the production unit shown in Fig. 7 (top), which has a striking resemblance to the original breadboard model.

This type model is also used extensively in laying out electrical and electronic assemblies, such as control panels and television chasses.

Full-Color Appearance Models. Great importance is attached, and rightly so, to the overall impression a consumer product makes on the general public. To a large degree, a product like the air conditioner in Fig. 8 has to sell itself through the initial impact its color and shape make on the observer.

The two experimental models in Fig. 8 were produced to precisely simulate the finished products, as far as outward appearance is concerned. Comparative studies could then be made by individuals and groups representing various phases of the company operation. Engineering could check the space available for internal parts and subassemblies; production the tooling aspects; purchasing the availability of materials; sales the pricing; marketing the mechanising procedures; and so on down the line.

Demonstrator Models. This is a broad classification generally associated with models that are wholly transparent, or have certain parts or assemblies made of transparent plastic. In about every instance, these models represent the finished product—full size if the prototype is of manageable size, like an aircraft powerplant; or reduced scale if it represents something impractical to handle, like the complete airplane assembly.

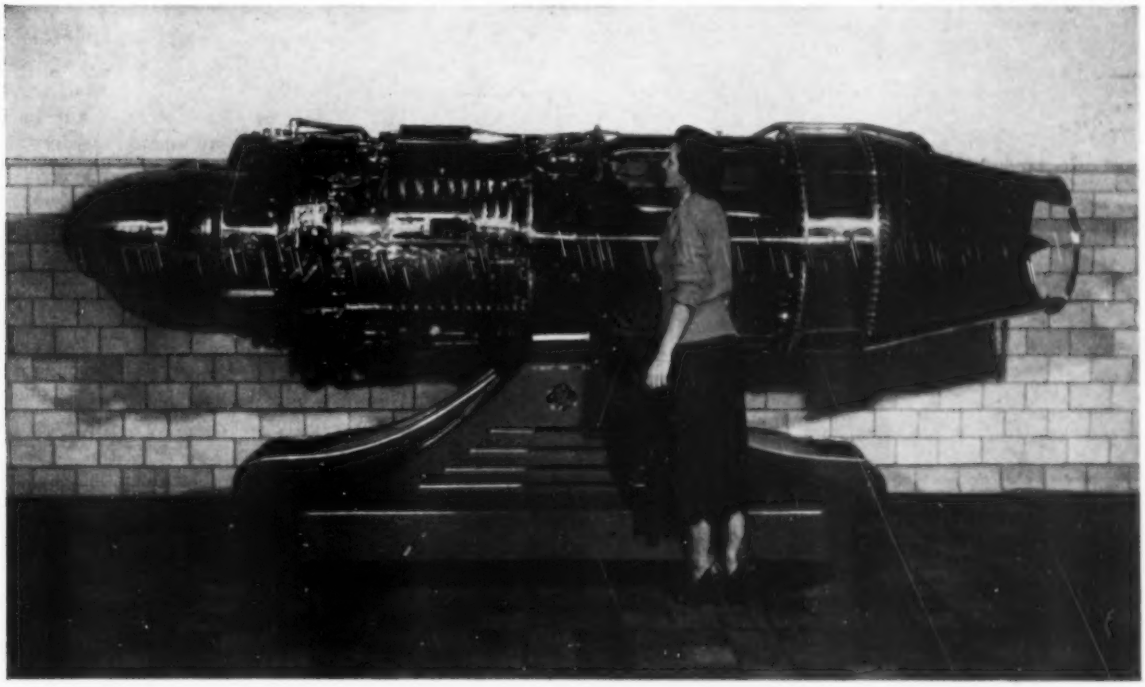
Actually, these transparent models are among the more expensive (exclusive of computers) to make or have produced. However, the property of transparency and its capacity for "catching the eye", in addition to the practical aspect of "seeing what goes on inside" seems to justify the cost.

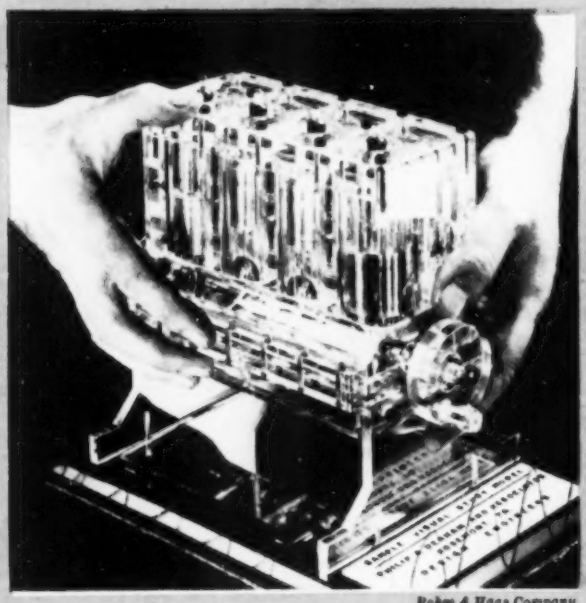
It is this last feature of exposing the inner details of a design that is of value from the technical viewpoint. The electric motor and pneumatic controller in Fig. 9, as well as the jet and piston engines and record changer in Figs. 10 through 12, represent products that lend themselves to various forms of the now-familiar demonstrator model.

The matter of explaining the design features of a product is especially significant in connection with the Tel-O-Set controller and electric motor shown in Fig. 9. The controller is one of several elements in an automatic system for regulating continuous processes. These units consist of several coded, interchangeable sections separated by diaphragms and containing several drilled passages. Their response is to differences between two air pressures—one corresponding to the measured variable and the other

Fig. 10—Working model of J-47 jet engine combines use of transparent housings and assemblies with cutaway sections. Such a model has several practical functions among which are parts mock-ups, operational instruction media, sales promotion and "prestige" demonstration at meetings and expositions.

General Electric Company





Rohm & Haas Company

Fig. 11—Visual study model of four-cylinder gasoline engine, by Philip A. Derham and Associates, Rosemont, Pa., is machined from solid, clear Plexiglas. Hand-operated model measures approximately 8 by 6 by 4½ in., and illustrates the action of all moving parts. In machining, some tolerances as small as 0.001 in. were held.

Victor Division, Radio Corporation of America

Fig. 12—Demonstration model of 45-rpm record changer reveals design features such as the simplicity and compactness of drive mechanism. While changer is in full operation, other selling points pertaining to speed and quietness of change cycle can be effectively proven.

to the set or fixed reference point.

This same technique applies to the electric motor in Fig. 9. As this type product represents a highly competitive market, an effective and thorough selling job must be done on the design as a whole, and specific constructional features in particular. The demonstrator model with its attractive "look" is often the answer.

As is typical with aircraft power plants, the jet engine in Fig. 10 is essentially a cut-away model with some of the housings made of transparent sheet plastic. These models are useful to engineers in several respects. They are an accepted medium through which the operational principles of a complex machine can be explained; and as part of a training course for young engineers, they are ideal.

A second use for these models is their role as a "guinea pig" or mock-up on which to experiment with redesigned parts. Also, new accessories can be checked for mounting difficulties or interference with adjacent components and projections.

A third function is strictly for demonstrational purposes. In this instance, it might be airline or Air Force engineers who want to see certain design features. And in the last analysis, it is the airplane service mechanics who must know all the constructional and operational details if they are to do their job properly.

This third model function comes under the heading of "exhibit" in the case of the small internal combustion engine in Fig. 11. This four-cylinder assembly was machined from Plexiglas to tolerances as close of 0.001 in. It illustrates the action of various moving parts, some of which (pistons and connecting rods, for example) are made of metal.

SELECTED REFERENCES

1. Glen Murphy, *Similitude in Engineering*, the Ronald Press Company, New York, 1950.
2. M. M. Leven, "Photoelastic Stress Analysis Useful in Design of Metal Parts," (Parts I & II), Westinghouse Electric Corporation.
3. F. B. Seely & R. V. James, "The Plaster Model Method of Determining Stresses Applied to Curved Beams," University of Illinois, Engineering Experimental Station Bulletin 195.

Check-Lists for Springs

Design specifications and engineering drawings for springs frequently lack information that is vital to their procurement or manufacture. Also, detailing and dimensioning practices are not usually consistent, even within a single organization, Result: confusion, delays, and increased costs. These check-lists will help avoid such pitfalls; they are based on practices recommended and used by the Ford Motor Company. Before a design layout or drawing involving one of the many spring types is released, be sure that all of the data listed below is specified.

COMPRESSION SPRINGS:

1. Material, with company designation or SAE number.
2. Wire diameter, with tolerances. See Tables I.
3. Spring dia with tolerance (Table II). If spring works over a rod, rod dia and ID of spring should be included. When spring operates over a rod and in a hole, rod and hole sizes and controlling spring dia should be given. Also, allowance should be made for increase in OD as spring is compressed.
4. Direction of coiling. When not important, it should be specified as optional.
5. Total number of coils, including fractional coils.
6. Solid height should not be specified unless required. If a limiting value is necessary, it should be given as a maximum dimension. Wire dia used for determining solid height should be the nominal value plus tolerance. If finish such as cadmium plating is used, dia should be increased further.

Table I—Wire and Coil Tolerances

Type of Wire	Wire Dia	Tolerance, in.	Coils	Coil Tolerance
Music wire	to 0.026	±0.0003	For each 10 coils over 10	±1 coil for extension and torsion springs
	0.027 to 0.063	±0.0005		
	0.064 to 0.250	±0.0010		
Hard-drawn or oil-tempered carbon steel wire	to 0.075	±0.001		
	0.076 to 0.0375	±0.002		
	0.376 and larger	±0.003		
Valve spring quality and alloy steel wire	to 0.148	±0.001		± ½ coil for compression springs
	0.149 to 0.177	±0.0015		
	0.176 to 0.375	±0.002		
	0.376 and larger	±0.003		

Table II—Manufacturing Tolerances for Cold Wound Coil Springs

Mean Coil Dia, in.	Dia Tolerance, in.		Free Length, in.[1]	Free Length Tolerances[2]			Active Coils	Load Tolerance, Percent	Rate Tolerance, percent[3]
	Spring Index			Open Wound		Close Wound			
	3 to 7.9	8 to 15		Spring Index 3 to 7.9	Spring Index 8 to 15				
1/8 or less	±0.003	±0.004	1/2 or less	±0.025	±0.040	±0.020	3 or less	±15	±10
1/8 to 1/4	±0.004	±0.006	1/2 to 1	±0.035	±0.060	±0.030			
1/4 to 1/2	±0.006	±0.010	1 to 2	±0.050	±0.080	±0.040	3 to 9	±10	± 8
1/2 to 1	±0.010	±0.016	2 to 4	±0.080	±0.12	±0.060			
1 to 2	±0.016	±0.025	4 to 8	±0.12	±0.19	±0.095	9 to 15	± 8	± 6
2 to 4	±0.025	±0.042	8 to 16	±0.22	±0.30	±0.150			
4 to 8	±0.042	±0.063	16 to 32	±0.35	±0.45	±0.225	Over 15	± 7	± 5

[1] When loads are specified, free length may be shown as an approximation and no tolerances applied.
[2] Free length tolerances for extension springs are for measurements inside-to-inside of hooks.
[3] The spring rate shall be determined between 20 and 60 percent of total deflection when not already established by two specified loads.

7. Free length—but as an approximate dimension unless it is critical or load is not specified. See Fig. 1(A).

8. Type of ends. For most applications, one of the conditions shown in Fig. 2, will suffice. If special ends are needed, they should be detailed on the drawing. When axial squareness is important, a note specifying this also must be on the drawing.

9. Surface finish and stress relief requirements, if any. It is usually advisable to find out the supplier's normal procedure.

10. A load at a definite height, see Fig. 1(B). Do not specify a load at some deflected distance from the overall free length. Tolerance in pounds is desirable.

11. Spring rate—max and min values preferably—in lbs per in. of deflection.

12. Abnormal operating conditions. For example, elevated temperatures, corrosive atmospheres, etc. should be noted.

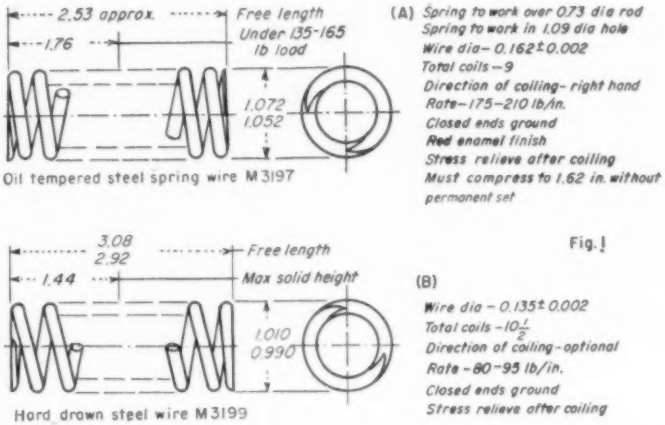


Fig. 1

Fig. 1—Recommended form for drawing a compression spring. For common types only 2½ coils on each end need be shown; intervening coils are indicated by phantom lines. Springs having 5 coils or less should show all coils. Design requirements determine whether (A) or (B) should be used. See check-list.

EXTENSION SPRINGS:

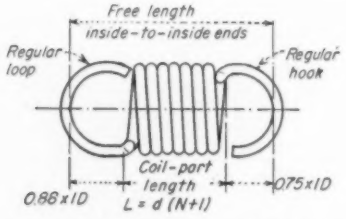


Fig. 3—Typical extension spring with regular loop on one end and regular hook on the other end. Special extended ends are often used to increase the free length without increasing the coil-part length dimension.

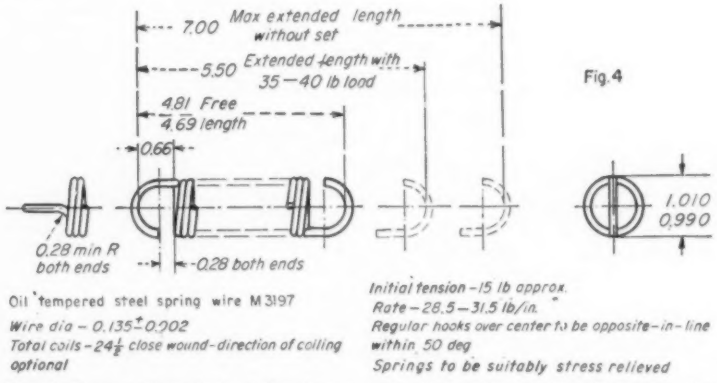

7.00
Max extended length without set
5.50
Extended length with 35–40 lb load
4.81 Free
4.69 length
0.66
0.28 min R both ends
0.28 both ends
1.010
0.990
Oil tempered steel spring wire M3197
Wire dia – 0.135±0.002
Total coils – 24½ close wound – direction of coiling optional
Initial tension – 15 lb approx.
Rate – 28.5–31.5 lb/in.
Regular hooks over center to be opposite-in-line within 50 deg
Springs to be suitably stress relieved

Fig. 4

Fig. 4—Suggested method of drawing an extension spring with typical notes that might be required. These notes should be a part of the detail-drawing.

1. Material with appropriate company designation or SAE number.

2. Wire diameter, with permissible tolerance.

3. Outside diameter with tolerance. If restricted by space limitations, maximum value should be specified.

4. Direction of coiling. Unless critical, it should be specified as optional.

5. Total number of coils, including fractional coils.

6. Coil part length for open wound extension springs—as approximate dimension. This is the length measured over-all coils, Fig. 3. Do not specify coil-part length for close wound springs. See Fig. 4.

7. Free length. Give as an approximate dimension unless critical. If critical, include tolerance. Free length is the dimension inside-to-inside hooks or loops when spring is in free or unloaded position.

8. Style of ends; see Fig. 5. Their angular position and hook openings should be shown on drawing. For close wound springs, tolerance on angular relationship of ends should be approximately two degrees per coil, but not less than 10 degrees. Forming radius at hook or loop should not be less than twice the wire diameter.

9. A load with tolerances, when required. Should be specified at a definite extended length of spring measured

Styles of Ends—Compression Springs

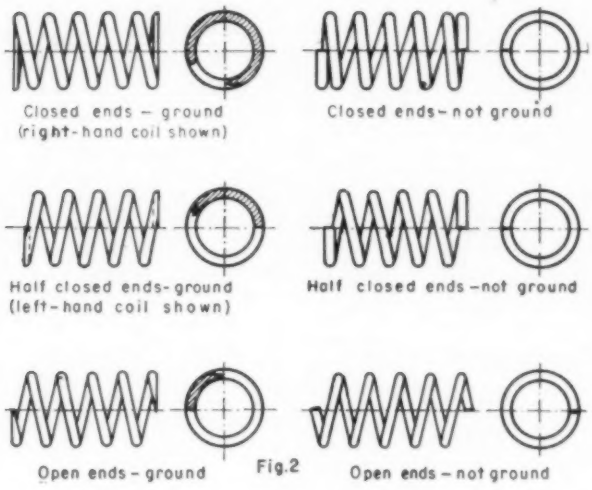

Closed ends – ground
(right-hand coil shown)
Closed ends – not ground
Half closed ends-ground
(left-hand coil shown)
Half closed ends – not ground
Open ends – ground
Open ends – not ground

Fig.2

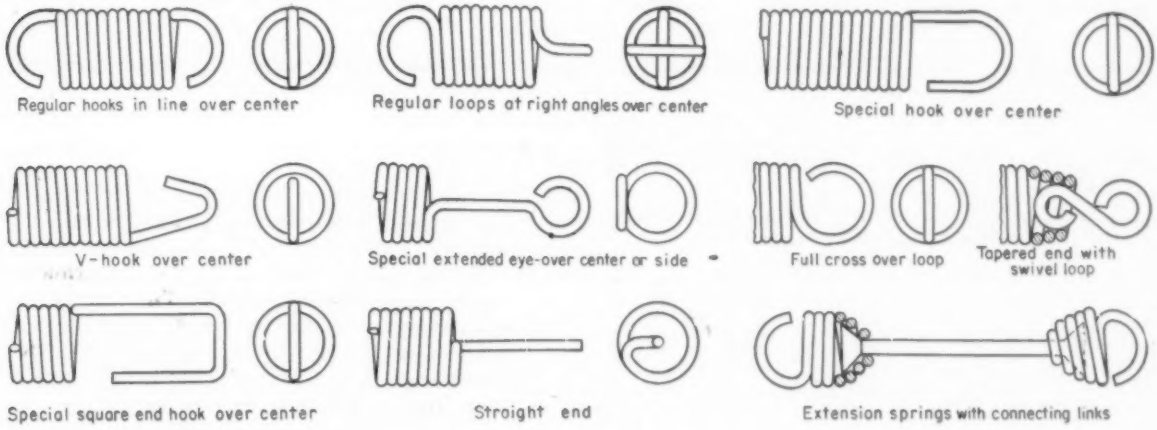
Active Coils and Maximum Solid Height of Cylindrical Compression Springs of Round Wire

Style of Ends	Active Coils	Maximum Solid Height[1]
Open ends, not ground	$N = Nt$	$d(N_T + 1)$
Open ends, ground	$N = N_T - \frac{1}{2}$	$d(N_T + \frac{3}{4})$
Half-closed ends, not ground	$N = N_T - \frac{3}{4}$	$d(N_T + 1)$
Half-closed ends, ground	$N = N_T - 1$	$d(N_T + \frac{1}{4})$
Closed ends, not ground	$N = N_T - 1\frac{3}{4}$	$d(N_T + 1)$
Closed ends, ground	$N = N_T - 2$	$d(N_T)$

Where N_T = total coils, N = active coils, d = wire dia. in.

[1] For electrolytic or chemical finishes add 0.001 and for enamel finishes add 0.002 to the wire size in order to determine the maximum solid height.

Styles of Ends—Extension Springs


Regular hooks in line over center
Regular loops at right angles over center
Special hook over center
V-hook over center
Special extended eye-over center or side
Full cross over loop
Tapered end with swivel loop
Special square end hook over center
Straight end
Extension springs with connecting links

inside-to-inside hooks or loops—not at some deflected distance from the free length. Preferred method to specify a load is with maximum and minimum values. If only one load is given, spring rate in lbs per in. of deflection with permissible tolerance should be given.

10. Maximum length to which spring must extend without taking permanent set.

11. Initial tension, if required by load requirements—as an approximate value. Note should be on drawing indicating if springs must be stress-relieved to maintain loads.

12. Type of finish.

13. Abnormal service conditions if any are expected.

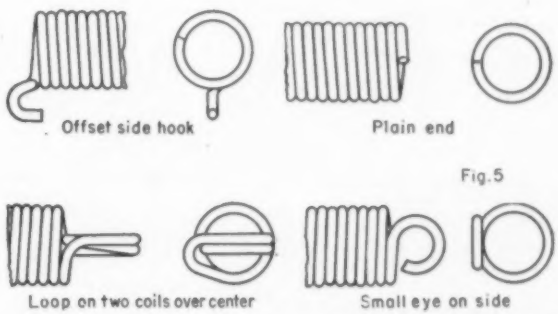


Fig.5

(continued on next page)

TORSION SPRINGS:

1. Material with company designation or SAE number.
2. Wire diameter, with the permissible tolerance.
3. Inside diameter with tolerance. If spring works over a rod, diameter of rod should be listed. See Fig. 6. Rod diameter should be approximately 90 percent of the minimum inside diameter.
4. Direction of coiling. To absorb torque in clockwise direction, spring must be wound counterclockwise.
5. Total number of coils in the free position.
6. Dimension, with tolerances, of the coil-part length of open-wound springs. Coil-part length of close-wound springs should be given as a maximum dimension only. Note that the number of wire thicknesses is one greater than the number of coils, and that the actual number of coils is increased by angular deflection of the spring.
7. Dimension of over-all free length with tolerances. This is the greatest length measured parallel to the spring axis when spring is in free position.
8. Angle between ends at zero load when not otherwise established—as an approximate angle.
9. Style of ends. Should be dimensioned adequately for fabrication. See Fig. 7.
10. Finish requirements.
11. Torque in pound-inches at both initial (installed) position and final working position—with tolerances. Both initial and final positions should be defined by an angle between ends.
12. Stress relief, if required.
13. Abnormal service conditions. Also, any special tests required to insure satisfactory service.

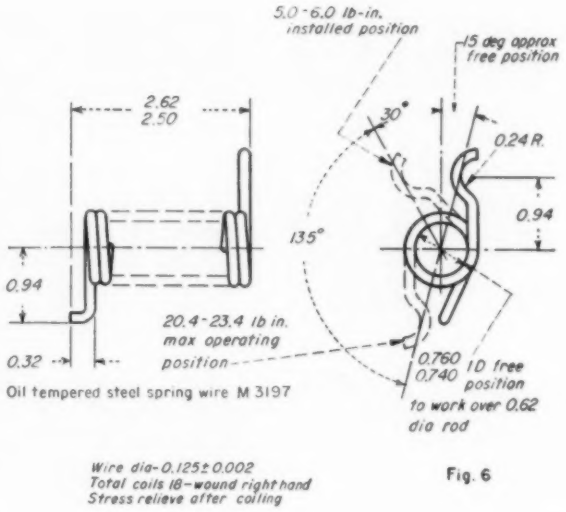


Fig. 6

FLAT WIRE SPIRAL SPRINGS:

Table III—Tolerances for Carbon Steel Flat Spring Wire

Wire Thickness, in.	Tolerance, in.	Wire Width, in.	Tolerance, in.
0.028 to 0.058	±0.0015	to 0.156	±0.005
0.058 to 0.160	±0.0020	0.156 to 0.625	±0.010

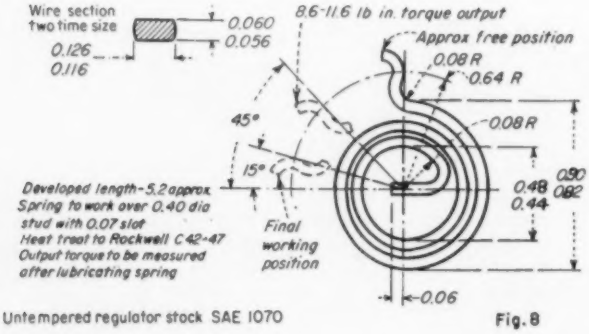
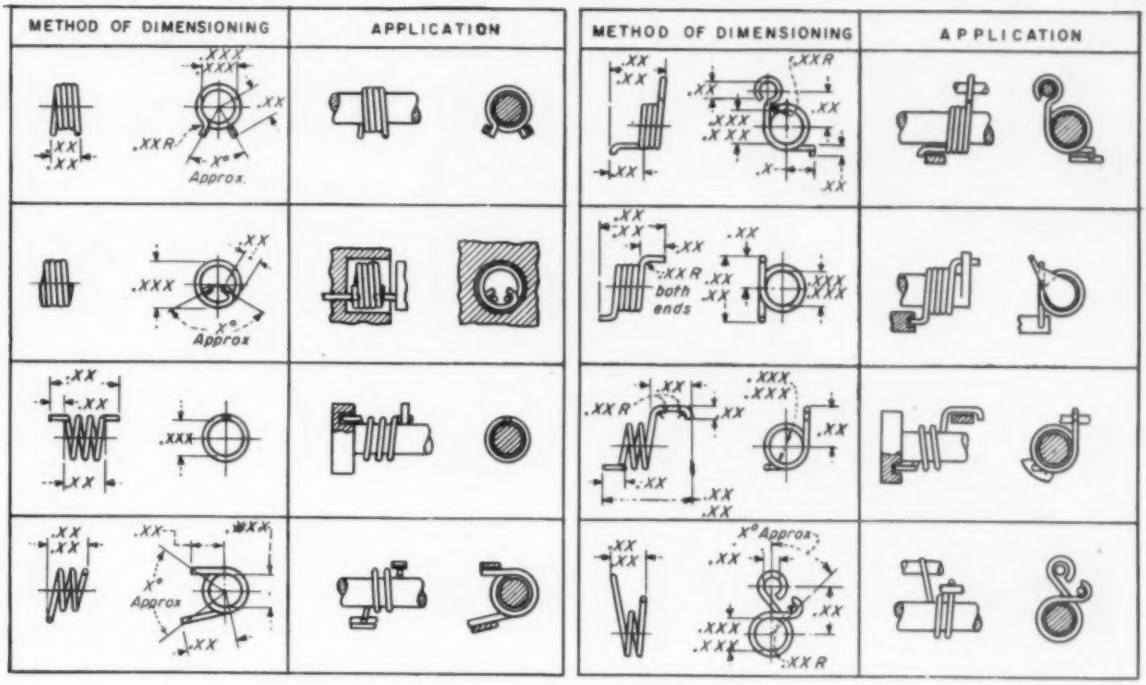


Fig. 8

1. Material with company specification or SAE number.
2. Wire section. Width and thickness dimensions should be shown with tolerances, Table III, or an enlarged view of section. See Fig. 8.
3. Approximate developed length of spring to nearest tenth of an inch. Developed length includes active length and material required for ends.
4. Inside diameter with tolerances. On drawing, ID should be measured at right angles to the center bar. If spring is to fit over a slotted stud, it should be noted on drawing. When some other fastening method is used, an auxiliary view is recommended if details are not obvious.
5. Outside diameter in the free position with tolerances. This dimension should be measured over all coils and along either the vertical or horizontal center line, whichever gives the larger dimension.
6. Dimensions of ends.
7. Angle formed by intersection of a line from points of loading on outside hook to spring axis, and either the vertical or horizontal center line of spring

Fig. 7—Styles of Ends and Typical Applications for Torsion Springs



should be given in free position as an approximate angle.

8. Required load in pound-inches with tolerances should be given at loaded position. This position should be specified as an angle in degrees. When more than one loaded position is specified, angular relationship between them should be noted.

9. Stress relief, if required.

10. Type of finish.

11. Special service or test requirements.

BELLEVILLE WASHERS:

1. Material and hardness. Use standard designations if possible.

2. Inside and outside diameters with tolerances. See Table IV.

3. Thickness with tolerance. See Fig. 9.

4. Definite load is required at a specified height, when required, tolerance should be given on compressed height rather than load. Free height should be given as an approximate dimension.

5. If springs must withstand frequent oscillations, all sharp edges should be removed.

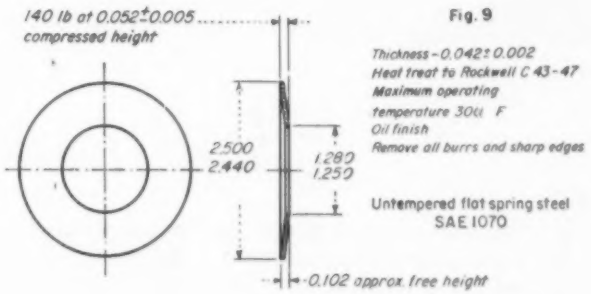
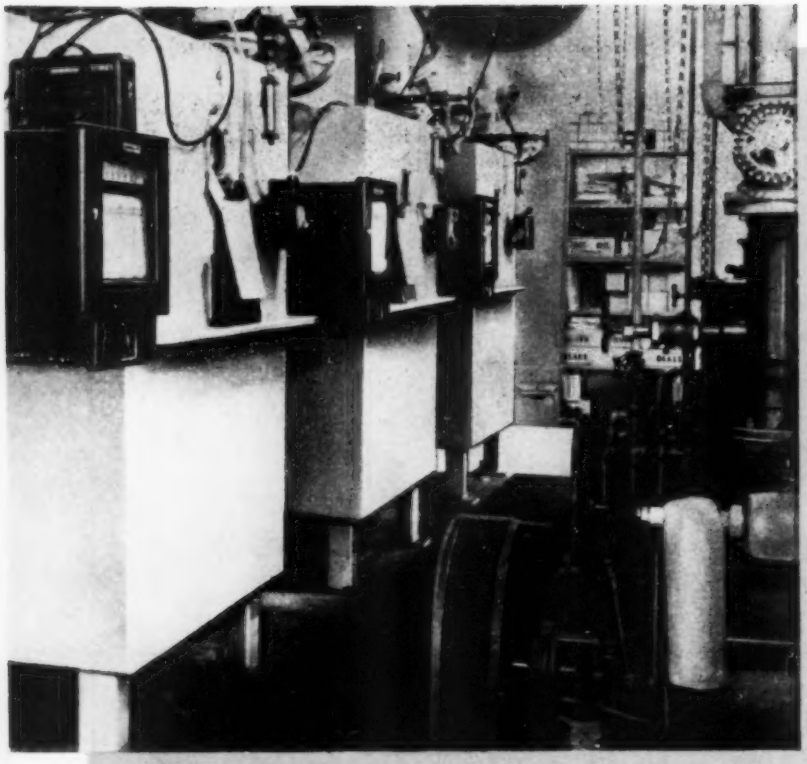


Fig. 9

Table IV—Commercial Tolerances for Belleville Washers

Outside Dia, in.	OD Tolerance, in.	ID Tolerance, in.	Outside Dia, in.	OD Tolerance, in.	ID Tolerance, in.
to ½ incl.		+0.015 −0.000	4 to 7	+0.000 −0.090	+0.090 −0.000
½ to 1	+0.000 −0.020	+0.020 −0.000	7 to 12	+0.000 −0.125	+0.125 −0.000
1 to 2	+0.000 −0.030	+0.030 −0.000	over 12	+0.000 −0.187	+0.187 −0.000
2 to 4	+0.000 −0.060	+0.060 −0.000			



Blood plasma dehydrating unit showing vacuum pumps, McCleod type vacuum gages and Electronik controllers. Photo—Sharpe & Dohme Inc.

Techniques and

C. C. ROBERTS and W. W. O'HARA
Application Engineers, Industrial Division, Minneapolis-Honeywell Regulator Company

TWO TYPES of instruments are used in the measurement of pressures below atmospheric:

1. The direct measuring type in which pressure is indicated by a displacement, where the displacement is caused by a force exerted as a result of the pressure.

2. The inferential type in which pressure is indicated by measuring some other physical property of the atmosphere that is proportional to its absolute pressure.

The direct measuring units are used in the range from 10 to 760 mm of

DIRECT MEASURING GAGES

1. SPIRAL GAGES. The spiral type actuating element, used widely in industrial compound vacuum and pressure gages, is basically a Bourdon tube wound in the form of a flat spiral. It gives a summation of the end movements of a number of tubes. The spiral does not require a sector and pinion to give sufficient pointer travel, and is directly connected to the pin or indicator shaft by a single link. This direct linkage gives minimum friction, inertia and lost motion, and increases the instruments accuracy and speed of response. Bronze spiral elements are available for compound vacuum and pressure measurement ranges between approximately 6.5 and 15 pounds per square inch.

2. INTERMEDIATE AND LOW PRESSURE SPRING AND BELLOWS. The intermediate range spring and bellows element, (A), is available with full scale ranges between 10 and 30 in. of mercury. It is used in the lower pressure regions where Bourdon and spiral elements are not sensitive enough to give an accurate indication. The unit consists of a bronze bellows enclosed in a bellows shell. The space between the bellows and the shell is exposed to the pressure to be measured, and the bellows moves vertically against a spring. A rod resting on the bottom of the bellows transmits the motion through a suitable linkage into pen or indicator movement. This type of element is

for Measuring Controlling Vacuum

mercury. Included in this category are spirals, spring and bellows, oil immersed suspended bells and mercury U-tubes. One exception is the direct type McLeod gage which covers a range from 10^{-6} to 1.0 mm of mercury.

Essentially, there are two types of inferential gages, the Pirani or thermal type and the ionization type. The thermal vacuum gage covers ranges of approximately 0-500 and 0-1,000 microns of mercury absolute. The ionization gage is used in the range from 0.001 to 0.4 microns absolute.

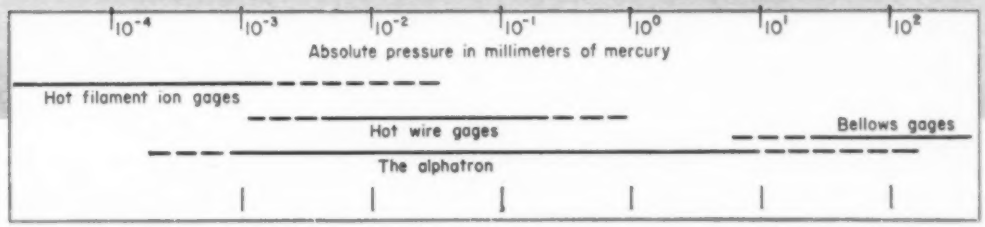
The following diagrams show several of the common types of vacuum measurement and control devices together with operating principles and performance characteristics.

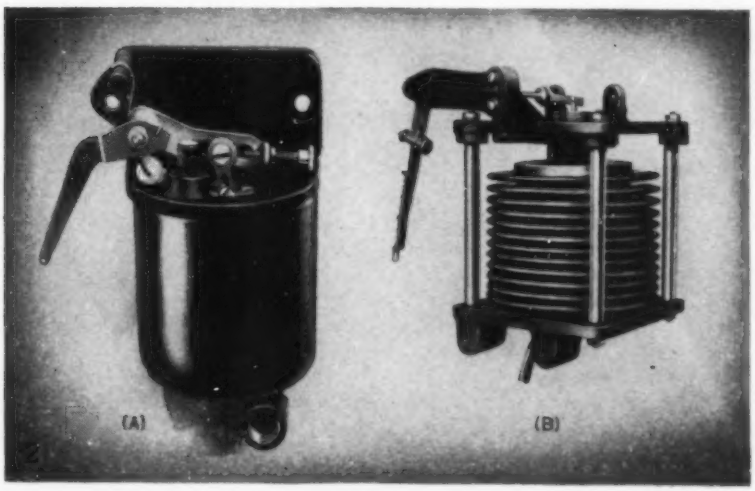
PRESSURE EQUIVALENTS

psi	Mercury		Water
	in.	mm	in.
1	2.036	51.71	27.70
0.4912	1	25.40	13.61
0.0193	0.0394	1	0.536
0.0361	0.0735	1.87	1

Notes: Mercury at 0 C
Water at 15 C
1 micron = 10^{-3} mm of mercury

VACUUM SPECTRUM SHOWING RANGES OF MEASURING DEVICES



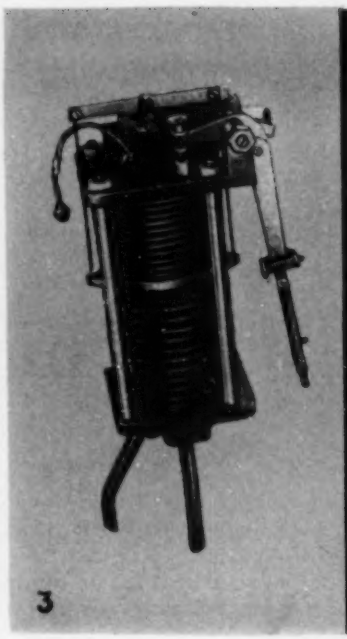


capable of exerting a large force per unit change in pressure.

The low pressure spring and bellows unit, (B), has a large bronze bellows. The pressure to be measured is connected internally and bellows movement is balanced by the externally mounted spring. For vacuum and compound ranges an internal stainless steel spring is mounted in tandem with the external spring. The second spring opposes the collapse of the bellows under partial vacuum conditions. This unit is used for minimum full scale vacuum or compound ranges up to 80 in. of water. Because of the size of the bellows, it develops ample power for use in the lowest pressure ranges.

3. Compound Spring and Bellows. This absolute pressure element consists of an (upper) evacuated bellows (sealed at nearly a perfect vacuum) containing a calibrating spring, and a (lower) actuating bellows connecting internally with the measured pressure. The top of the evacuated bellows and the bottom of the actuating bellows are rigidly attached to supporting castings, while the adjacent ends of each bellows are attached to a movable plate.

Since the exterior of both bellows is subjected to the same barometric pressure, variations in this pressure act equally on each bellows. Thus, with their movements being opposed, any change in the position of the common plate represents a variation in the true absolute pressure of the measured source. This element is suitable for absolute pressure measurements between 0 and 25 psi, with full scale ranges as low as 0 to 100 millimeters of mercury.



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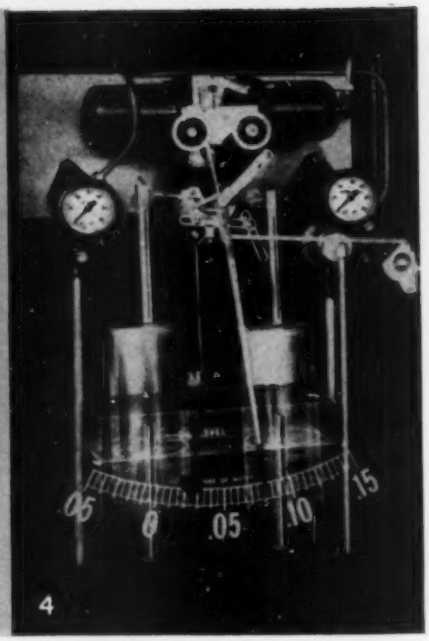


4

4. Inverted Bell Gages. The use of the inverted bell type of pressure gage is confined to applications requiring a sensitive, small range gage. It is available in a single inverted bell model for measuring static pressures, or in a double inverted bell model (as shown) for differential pressure measurement and control where compensation is required.

The single bell model consists of an inverted bell suspended in oil, and arranged so that the measured pressure raises the bell and moves a counterweighed balance beam. Movement of the beam is transmitted through a mechanical linkage to a pressure indicating assembly. A wider field of application is found for the double bell model. This type has two liquid-sealed, oil-immersed, inverted bells. As shown in the diagram, pressure is admitted under each bell.

In effect, the double bell design indicates the difference in pressure between the two supply lines and for this reason the instrument is adapted to the measurement and control of small pressure differentials such as encountered in measuring air flow.

These types of pressure instruments are sensitive to within plus or minus 0.0005 in. of water and are available in scale ranges of 0-2 in. of water vacuum to 0-5 in. of water gage, with spans as low as 0.2 in. of water.

5. McLeod Type Vacuum Gage. This type of gage measures pressure (vacuum) by sampling a definite amount of the rarefied atmosphere of the vacuum system and compressing it to a smaller volume at a higher pressure. This is done by turning the gage periodically, (A), from the charging position to the reading position. The higher pressure obtained in the reading position is indicated by the level of the mercury column in the capillary tube. By using Boyle's law, the scale can be calibrated to indicate the pressure in the evacuated system.

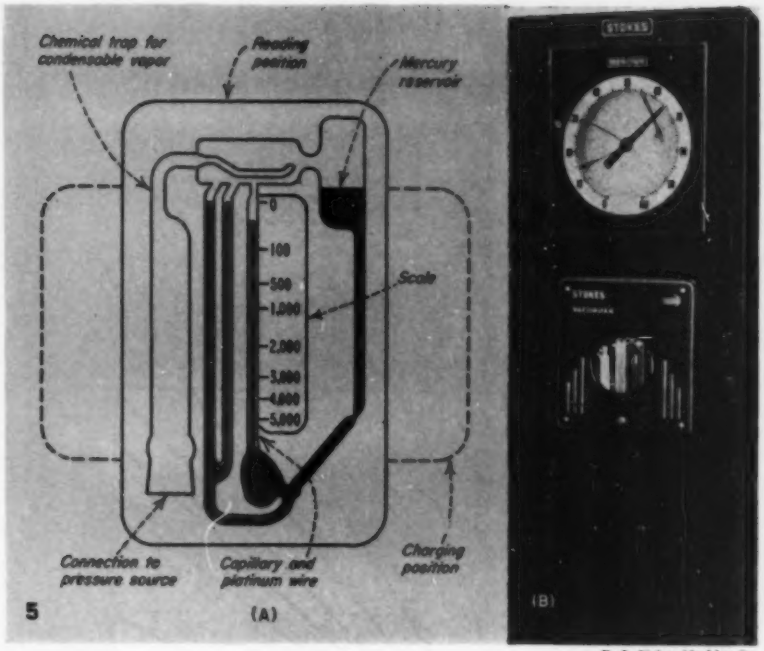
A resistance-type electrical measuring system which changes resistance in accordance with changes in mercury level can be used to indicate the height of the mercury in the measuring tube. Thus, this resistance value is a measure of the pressure in the vacuum system. A recording potentiometer, (B), can be used to indicate and record this resistance in terms of pressure. With a high-speed, continuous balance recorder, the sampling-measuring cycle time of the gage is reduced so that practically a continuous record can be obtained.

The gage is designed to correct for errors which might result from the presence of condensable vapors in the vacuum system. Thus, the true total pressure including the condensables as well as air is measured, regardless of the chemical composition of the gas in the vacuum system.

INFERENTIAL MEASURING GAGES

6. Pirani High Vacuum Gage. The Pirani gage operates on the thermal principle. The heat loss from a filament of resistance wire, carrying a constant current, is a function of the pressure surrounding the filament. This heat loss results from conduction and convection which are dependent on the number of gaseous molecules surrounding the filament and thus on the pressure. In the low pressure range, from approximately one micron to one millimeter of mercury, conduction and convection properties change noticeably with changes in pressure. This type of gage is well suited to this range.

The circuit is fundamentally that of a Wheatstone bridge. The open-ended tube represents the enclosure for the coil of resistance wire which is exposed to the vacuum system. The closed tube is sealed off at a pressure lower than one micron of mercury and houses a resistance coil which acts as a temperature compensating element to



5 P. J. Stokes Machine Co.

correct for any false indications of pressure that might result from ambient temperature variations. The remaining two arms of the bridge circuit are equal fixed resistances.

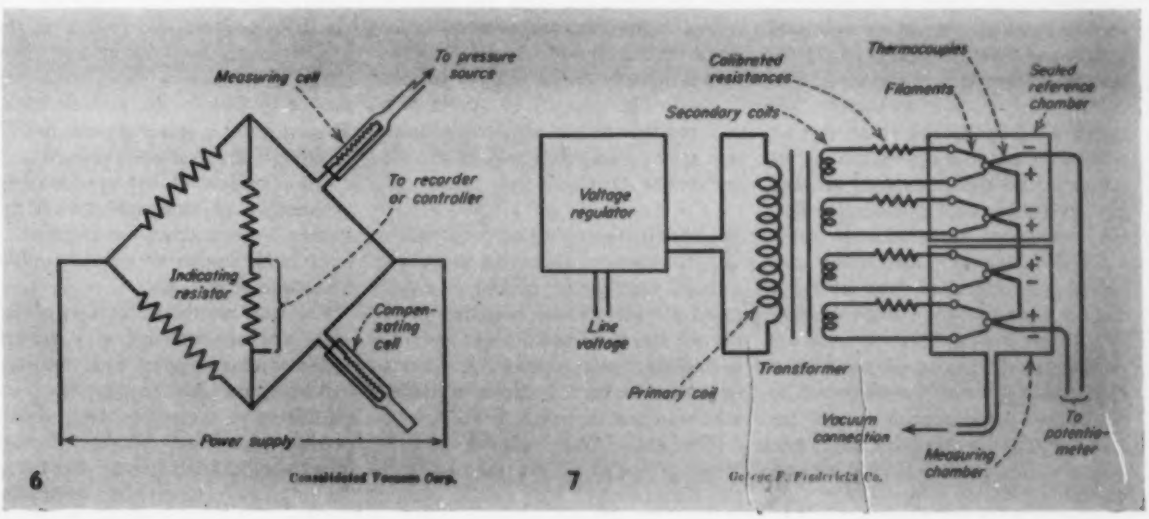
With a constant power source, the resistance of the filament in the gage tube varies with its temperature which in turn is proportional to pressure. The bridge circuit is balanced when the resistances of all four legs are equal. A change in resistance of any one of the legs results in an unbalance proportional to the change in resistance. Since the compensating element is maintained at fixed pressure, its resistance can only change as a result of variation in ambient temperature. As a result of this compensating effect, the amount of unbalance of the bridge is entirely a function of measured pressure.

The current flow in the indicating arm of the bridge and thus the voltage drop across the indicating resistor are proportional to pressure. This voltage can be used to actuate a potentiometer which can be calibrated in terms of pressure and used to indicate, record and control the vacuum.

7. THERMOCOUPLE TYPE THERMAL GAGE. Four filaments are each uniformly heated by current from four separate secondary windings of the power transformer. The current to each filament is maintained at a constant value by means of the calibrated resistors in series with each filament circuit. The voltage regulator prevents changes in filament heat which might result from line voltage variations. These devices are required to obtain accurate gage operation.

Two of the four filaments are in the measuring chamber of the gage. The other two filaments are in the reference chamber, sealed during manufacture at a pressure of one micron of mercury. Filament temperatures are measured by four small sensitive thermocouples. These thermocouples are connected so that the two in the reference chamber and the two in the measuring chamber are each connected in series to give a higher output, while the connections to the two sets of the thermocouples are such that their outputs are opposed.

Thus, the difference between the two opposing output emf's (which is the difference between the emf produced in the reference chamber at a pressure of one micron and that produced in the measuring chamber) is a measure of the difference in pressure between the reference chamber and the measuring chamber. For a pressure variation from one micron to 500 microns, this emf varies from 0 to about 19.2 millivolts. This signal can be fed to a servo-type, null balance potentiometer for control purposes.



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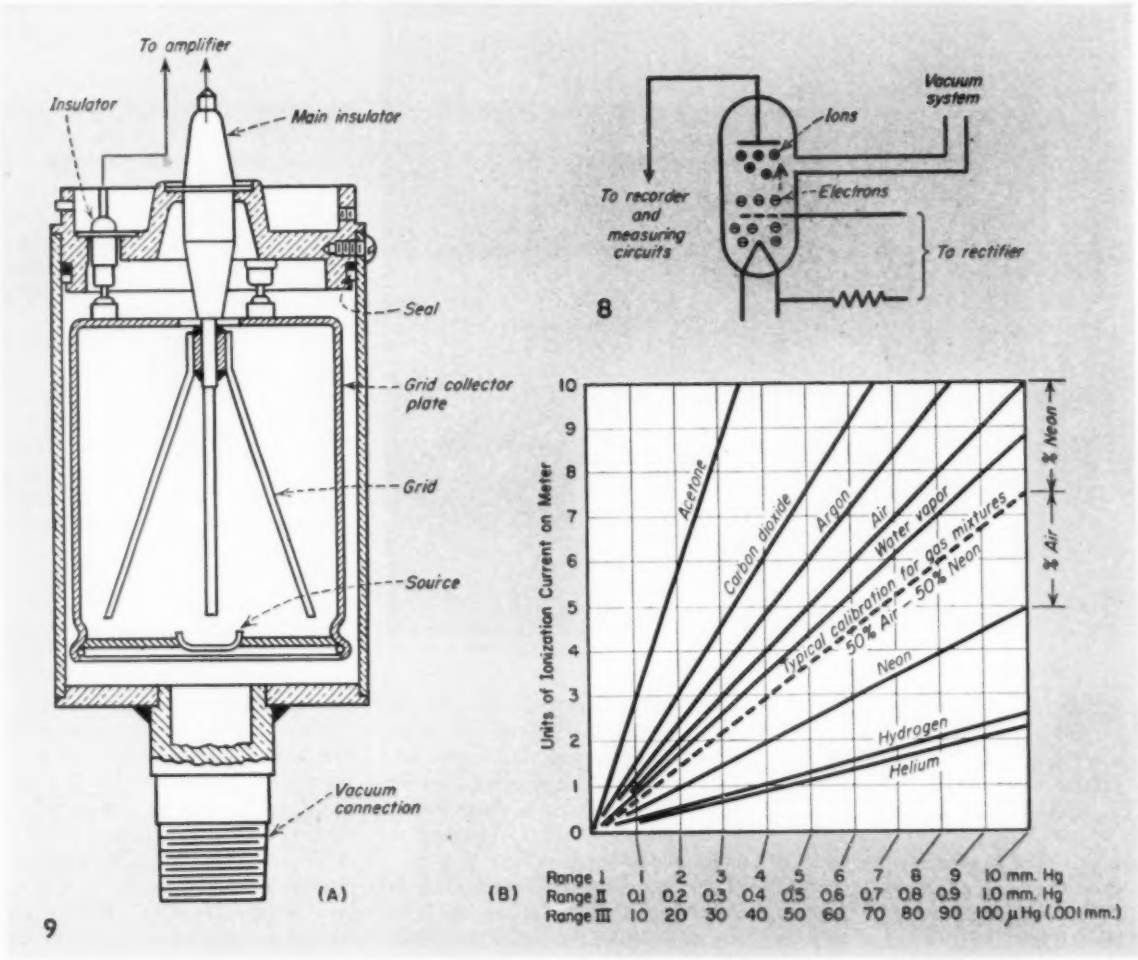


National Research Corp.

8. Hot Cathode Type Ionization Gage. The operation of the ionization type gage is based on the ability of electrons emitted from a hot filament to bombard the molecules of the residual gas in an evacuated system and thereby to cause an electric current to flow between suitable electrodes. The amount of current flow is directly proportional to the number of ions formed. This in turn is an indication of the amount of residual gas present, so that the current flow is a measure of the absolute pressure.

The hot filament is the cathode of a triode tube. The electron emission from the hot cathode is held constant by a bridge circuit. The electrons are attracted to the grid (maintained at a high positive potential with respect to the cathode) and carried on past the grid toward the plate by their momentum. The plate is held at a negative potential with respect to the grid, and repels the electrons causing them to be driven among the molecules of the residual gas. Thus, the gas molecules are subject to bombardment by the electrons, and ions are formed. These positive ions are collected on the plate. As a result, a current flows which depends on the number of ions formed. The intensity of current flow is a measure of the absolute pressure and after preamplification can be used for control or indication.

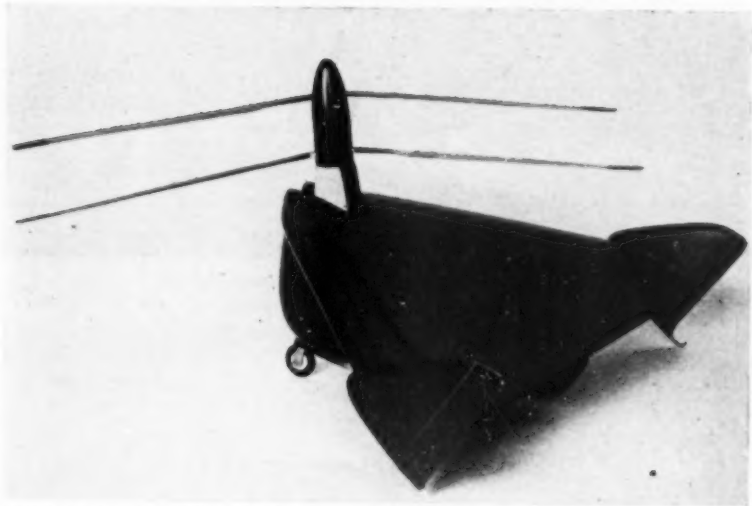
9. Alphatron Cold Cathode Ionization Gage. In this gage, a small quantity of radium is sealed in an all-metal vacuum chamber. Since the radium is in equilibrium with its immediate decay products, it gives a constant source of alpha particles which are the ironizing agent.

The gage, (A), operates on the same principle as do the ordinary hot-filament type. The radium source supplies alpha particles at a constant rate and at such a range that gas molecules in the ironization chamber collide with the alpha particles and become ionized by the loss of an electron. As these positive ions collect on the grid structure, they pick up a negative charge and cause a small ionization current to flow in the grid electrode. This current is proportional to the pressure in the evacuated system.

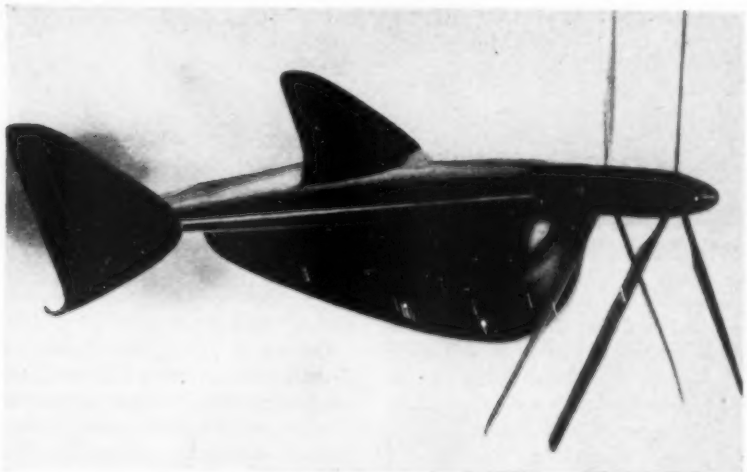
Since the current is proportional to the number of ions collected on the grid in a given time, the response is linear with respect to pressure, (B), regardless of the gas.

This unit has the advantages of the usual type of ionization gage (linear within working limits, total pressure indication and fast response to pressure changes) but many of the disadvantages (emission instability, short life, fragility, limited range and burnout in pressure surges) are overcome.

TECHNICAL NEWS



READY FOR TAKE OFF this delta-winged model plane has coaxial rotor-propeller in horizontal position. But . . .



. . . IN FLYING POSITION rotor-propeller swings down. This Dobson design illustrates one approach to building . . .

. . . CONVERTIPLANES

FOR TWENTY YEARS flying enthusiasts have been dreaming of an airplane that would 1) take off vertically, 2) change itself to high speed forward flight, and 3) change back to land vertically. They've called such a machine a convertiplane. Last month convertiplanes were making news again:

- In England, Fairey Aviation Ltd. released details of a new design called the Rotodyne. Biggest yet attempted, it will carry 40 passengers.
- In France, the new Sncaso S. O. 1310 Farfadet convertiplane is undergoing flight tests.
- In St. Louis, Mo., McDonnell Aircraft is working on two machines, a small unit for the Air Force and Army and a large Marine assault convertiplane. They expect to fly the small plane later this year.
- In Fort Worth, Texas, Bell Aircraft Corporation is putting together components of its model 200 convertiplane that has been ordered by the Air Force.
- In Bridgeport, Conn., Sikorsky Aircraft is studying a different approach embodied in the current Sikorsky Model S-57.
- In New Castle, Delaware, small Transcendental Aircraft, is working on a tilting rotor convertiplane.
- In Los Angeles, California, a group of engineers are building a prototype of a delta wing convertiplane that may fly as fast as 700 mph.

The Basic Problem

There are several reasons for the widespread activity. Commercial convertiplanes could revolutionize air transport because they need such small landing strips. They would make the helicopter, today's most promising new airplane for military and commercial applications, obsolete.

Basically, solving the convertiplane design problem means combining the lifting force of a helicopter rotor with the horizontal thrust provided by a propeller or jet engine.

Many patents have already been issued covering ways to convert a rotary-wing takeoff to a high speed forward flight condition and back. Some of the ideas are "Rube Goldbergish" in nature. But among the seriously watched approaches are four projects being backed by U. S. military financial sponsorship.

Government Sponsored Designs

McDonnell Aircraft has two contracts in the convertiplane field, one covers a small XL-25 convertiplane for the Air Force and Army, and the other a larger marine assault transport machine designated XHRH-1. Both of these utilize a rotor driven by jets located at the tips, which can lift the machine or lower it. The forward propulsion devices have not been disclosed. Presumably these are either another jet engine or engines, or propellers driven by engines.

In this type of convertiplane, the rotor idles without power while the convertiplane uses its forward propulsion. The little jets at the rotor tips are ignited again when it is time to land the aircraft vertically.

Bell Aircraft Corp. uses rotor-pro-

pellers which tilt through an arc of 90 deg. in their design. When the rotor-propellers revolve in a horizontal plane, they are expected to lift the convertiplane vertically. After cruising altitude is reached the rotors are tilted forward until they revolve in a vertical plane, so that they provide horizontal thrust, like a conventional airplane propeller.

Many designers consider this a very difficult mechanical solution to the convertiplane design problem, but one which will pay large dividends, if successfully achieved. The Bell design, is also expected to be ready for flight tests by early next year.

Sikorsky Model S-57 is another approach in the small convertiplane Air Force-Army competition. This design calls for braking the rotor to a stop and retracting it after cruising altitude is reached, then turning on forward propulsive thrust.

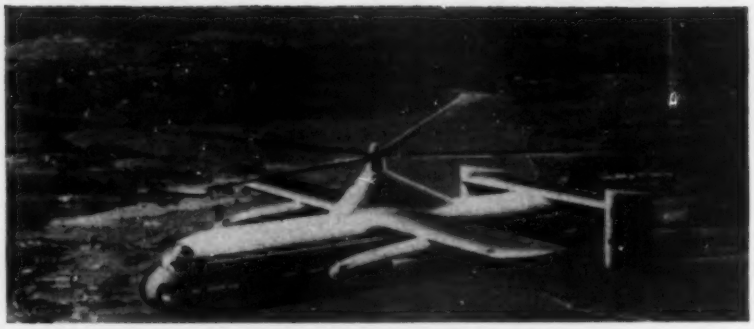
Wings and Rotors

Most of these designs make use of wings in addition to the rotors, to supply some lift in cruising flight.

Dr. Kurt Hohenemser, convertiplane student and aerodynamist at McDonnell claims that the use of a wing in a convertiplane design, does not necessarily mean a serious penalty in performance of the aircraft. He points out that most airplane wings are design compromises between good performance for takeoff, and at cruising altitude. In the case of the convertiplane, the wing could be designed to get the best performance at cruising altitude without attention to landing or takeoff. He thinks it might even have better performance than an equivalent fixed wing airplane.

Transcendental Aircraft Corp., is working on another tilting rotor convertiplane under Air Force prompting. Gyrodyne Corporation of America, on Long Island, has flown a compound helicopter which has rotors for lift and propellers for forward thrust.

Gerard P. Herrick of New York, flew his "Convertiplane" Model HV-1, in two configurations—as a conventional airplane, and as an autogiro with a free-wheeling rotor in 1931. His second Model HV-2A went a step further, and made the first successful conversions in flight. The machine appeared to be a biplane, but when the brake on the upper wing was released in flight, the wing became a rotor and turned to provide additional lift. Herrick is now sponsoring a modern design, with a similar biplane configuration, but with the addition of jet engines in the rotor tips.



FAIREY'S ROTODYNE will be a giant, jet-powered convertiplane.

SNCASE S.O. 1310 FARFADET convertiplane hovers over the ground.

The delta-wing convertiplane is being privately developed in California by a group under the direction of Franklin A. Dobson, head of structural research and development for guided missiles in the aerophysics lab at North American Aviation. The Dobson design will use a coaxial propeller-rotor mounted in the nose. As the craft shifts from vertical to forward motion, the rotor is swung from a horizontal to a vertical position.

Currently under construction is a prototype that will carry two occupants, and be powered by two McCulloch 4318 target engines developing 70 hp each, enough to push the model to a speed of 172 mph in level flight. It will have a maximum climb rate of 1,950 ft per min.

Dobson is aiming his airplane at civilian markets. But he claims a military model would be limited in speed only by available power once the propeller is in the forward position. He thinks his design could reach speeds around 700 mph with the proper power plants.

Best known of the recent foreign developments is the rather small British Fairey Gyrodyne, which at one time held the world speed record for rotary-wing aircraft.

A successor that Fairey Aviation Ltd. is now developing, is called the Rotodyne and will be one of the largest if not the largest compound rotary wing aircraft yet announced. It is to be powered by two turbines which will exhaust through the tips of a five-blade jet rotor, and by two other turbines which will drive propellers for forwar thrust. It is expected to accommodate 40 passengers (see above).

AVIATION PROPHECIES——

TO CELEBRATE THE 50TH ANNIVERSARY of aviation* E. H. Heineman, Douglas Aircraft's chief engineer and designer of the 1,238 mph Navy-Douglas Skyrocket, sat down and made some predictions about where the fast-paced aircraft industry might move next. Here are some typical excerpts from Heineman's look at the next twenty-five years.

On Jet Engine Transports: ". . . That jet engines will be in operation in the U. S. in the future is generally agreed to be a certainty. Because transport operations in this country are highly competitive, jet transports will not be built or placed into operation until it can be proven positively that they can compete economically with propeller-driven aircraft. . . ."

". . . It appears at present that jet transports will not attain a sound position economically until cruising speeds of approximately 500 mph are reached. This is 175 mph faster than the cruising speed of current transports. . . . Jets should be in extensive (commercial) operation by 1960."

On Speed of Commercial Aircraft: ". . . During the entire history of aviation, transport cruising speeds have increased at the rate of only about seven mph per year. This trend will continue, but with the advent of jet transports will jump about 100 mph. 500 mph by 1960, with 600 by 1970, appear to be goals possible of attainment, but with considerable expense and effort."

On Commercial Use of Helicopters: ". . . Based on present costs and principles it is doubtful if the helicopter will ever replace the automobile for the private citizen. Still, there is every indication that the helicopter industry will continue to prosper. . . . It is not hard to imagine helicopter service in the future transporting people from downtown locations to airports or to transport people from one community to another near by. Commercial uses of helicopters appear unlimited."

** The Wright Brothers made their famous flight in the first heavier-than-air flying machine at Kitty Hawk, North Carolina, December 17, 1903.*

On Atomic Power Plants: ". . . Perhaps the most outstanding development of the next quarter century will be the development of atomic power plants for aircraft. Atomic power plants will solve many of the present problems such as fuel weight that averages a third of the aircraft total weight, would be reduced to an almost insignificant amount. On the other hand, atomic power plants, as now conceived, have the disadvantages of requiring extensive and heavy shielding around reactors and radio-active components that at present make such a power plant impractical.

With future research and development, there is every indication that solutions to this high engine weight can be found and that atomically powered airplanes will become a reality."

On Rocket Transportation: ". . . Higher speeds (higher than 750 mph) are possible, but will probably require operating in the extreme upper atmospheres where the molecular spacing is so great that the aerodynamic heating problem is greatly reduced. This cannot be accomplished by piston, turboprop or jet engines as we now know them because they are dependent on oxygen in the air combustion of their fuel. Operations in the upper atmosphere will be dependent upon the development of rocket type power plants."

". . . For a long time to come, rocket engines will probably be limited to special military missions because the weight of oxidizer required to burn the rocket fuel subtracts seriously from the payload. The advantages of rocket flight have been indicated in the Navy-Douglas Skyrocket research plane that set its speed records at an altitude of 79,494 feet."

". . . With continuing research and improvement in chemical fuels there is every indication that during the next twenty-five years rocket transportation will be possible.

But satisfactory rocket transport will pose several problems: the serious problem of overcoming aerodynamic heating during acceleration within the atmosphere and upon the return to atmosphere; also there would be numerous aerodynamic and propulsion problems.

Rocket machines are possible in the next quarter of a century but whether they will be practical and meet competition of more conventional airplanes is somewhat doubtful unless a tremendous (research) effort is expended in this direction."

AMERICA'S MOST HEAVILY ARMED FIGHTER PLANE, Northrop Aircraft's Scorpion F-89D built for the Air Force, is undergoing fire control reliability tests in California. The permanent wing pods hold 2.75 in. folding fin air-to-air rockets. Present tests are aimed at checking the F89's electronic aiming and automatic triggering equipment. Previous tests proved that the airframe could take the heavy rocket recoil.

CHANGES AT NBS

WASHINGTON—If staff members at the National Bureau of Standards remember the summer of 1953 for a long time, it's little wonder. In the past two months the Bureau watched four of its biggest divisions move to another cabinet department, lost over $35,000,000 in military research projects, saw their own appropriation slashed a whopping 26 percent by an economy-minded Congress, and found formerly satisfied customers—other government agencies—shying away from using NBS facilities.

It all started when Congress reviewed Department of Commerce funds requested for the coming fiscal year. About the same time, NBS popped up in the Congressional spotlight (see opposite page), occupying a major role in the battery additive investigation. It looked like a good place to cut funds, so the lawmakers slashed almost two and a quarter million dollars off the Bureau's eight and a half million request for operating funds.

The Big Switch

Then at the end of July, Commerce Secretary Sinclair Weeks and Defense Secretary Charles E. Wilson agreed that the Pentagon should supervise its own research and development. That meant moving four NBS ordnance and electronic divisions, employing 1,600 scientists and engineers—one-third of the Bureau's 4,800 working personnel. Three of the divisions, based in Washington, will remain at Bureau Labs until the Defense Department can find space for them. The other, at Corona, Calif. is working on guided missiles and will probably be assigned to the Navy for supervision.

With the 1,600 employees went the $35,000,000 in defense funds that had been transferred to NBS to pay for military research and development.

All this adds up to a major setback for the men who have pushed the laboratory's growth. Only last year, funds came in from three sources:

(1) Money appropriated for the Bureau's direct operation, 2) Defense Department payments for military research, and 3) fees paid by other government agencies for technical services. The figures tell the story. In 1952 NBS spent between $55,- and $60,000,000:

NBS' Operation	$ 8½ million
Military Research	35 "
Other Agencies	15 "
Total	$58½ million*

* figures are approximate

The prospects for 1954 are bleak by comparison:

NBS' Operation	$ 6½ million
Other Agencies	10 "
Total	$16½ million

Scientists Dissent

This sudden reversal of growth for NBS has, for the most part, not met with the approval of government-employed scientists and engineers. The Defense Department is getting a somewhat dissatisfied group from NBS. Those staying behind aren't happy either. The technical men are reluctant to talk about the change, and there's some indication that they've been ordered not to discuss it. The ban, either real or imagined, has started a flock of rumors circulating in Washington scientific circles.

• Example: NBS' hard times can be traced to the AD-X2 affair. It is punishment for Bureau scientists who refused to change their findings about the battery additive and who supported Director Allen V. Astin when he was fired from his post.

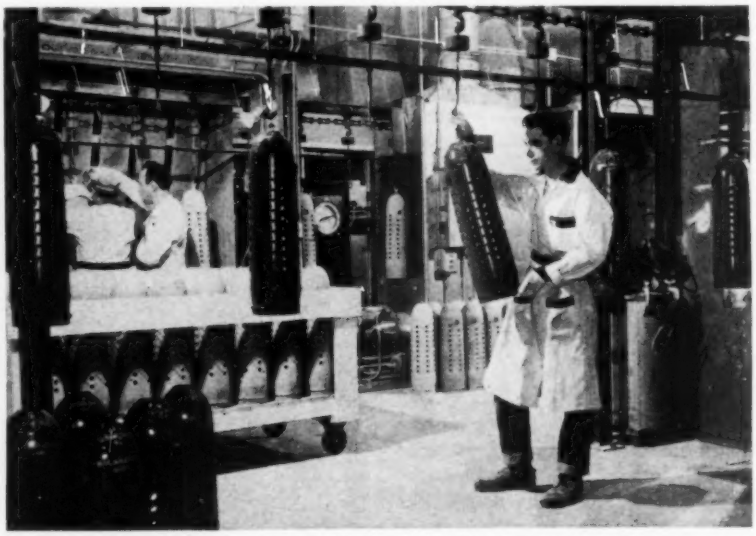
• Example: The "heat" has been applied to government agencies not to use Bureau facilities until they get the go-ahead signal from Commerce Department officials.

• Example: The Commerce Secretary did not defend NBS against Congressional budget cuts; further he did not properly represent what the Bureau is doing at appropriation hearings.

The bitterness of these charges indicates how deeply the scientists have been rankled. Many of those who are moving to the Pentagon have been NBS employees for periods up to 30 years. They dislike the idea of moving into a military department; they particularly don't want to be known as military scientists. Most of them got into that type of research because of emergency pressures, not of their own choosing. Some of them have been turning down lucrative offers from industry for years to stay at the Bureau. They like the atmosphere, the routine, and the academic freedom.

The Secretary's Views

Secretary Weeks, of course, is aware of the hard feelings. He's tried to allay scientists' fears by widely broadcasting his reasons for the change. The Secretary's avowed approach is to make "Commerce Department Bureaus of



FIRST CONVEYORIZED, mass production facility built to apply high temperature ceramic coatings to alloy steel components (like these jet engine combustion chambers) has gone into operation at Solar Aircraft Company's San Diego Plant. The fundamental development work in such coatings was accomplished at the National Bureau of Standards, and evaluation of such materials has been a project of long standing.

service to business and to cut off any non-business service functions". He has pointed out that NBS' remaining 13 divisions will continue to serve industry, with some minor simplification and tightening up.

According to Mr. Weeks, NBS was not set up to do military research. Now the agency will be able to concentrate on the function for which it was originally created—keeper of the nation's standards of weights and measures and related work on physical constants.

Supporting Mr. Weeks' views is Dr. Mervin J. Kelly, Director of the Bell Telephone Laboratories who is heading a committee that is investigating NBS' functions and organization.

SAFER EJECTION SEATS

PILOTS thrown from fast moving jet planes by automatic ejection seats always have one fear: will they clear the airplane? Engineers at Lockheed Aircraft Corporation have finally solved that problem with an ejection seat that uses telescoping guide rails to steer the seat out of the cockpit.

According to company engineers, the rails permit a more fully guided catapult stroke, giving the seat a high trajectory after ejection to gain additional clearance over the airplane. Three feet long, the rails guide the seat during the first 48 inches of travel. The new seats will be used on F-94C all-weather fighters.

AD-X2: STILL A QUESTION

WASHINGTON—After a short investigation, the Small Business Committee of the U. S. Senate gave up studying the merits of AD-X2, the much publicized battery rejuvenator. Despite a flood of testimony, the committee was unable to resolve the big point of contention: Does AD-X2 work?

Last spring Secretary of Commerce Sinclair Weeks decided that the National Bureau of Standards had not been objective in testing the battery additive, so he fired NBS' director, Dr Allen V. Astin (Product Engineering, May 1953, p. 137; June 1953, p. 137). When the dismissal launched a storm of protest in scientific circles, the Senate committee decided to start an inquiry. This is typical of the confusion unearthed by the senators:

On Contents

Jess M. Ritchie, inventor and manufacturer of the powder, refused to divulge his formula on the grounds that he was using secrecy instead of a patent to protect his discovery. According to Ritchie, "certain controls" and "trace elements" were the secret of AD-X2's success, and both defied detection by analysis.

Senator Hubert Humphrey, a registered pharmacist, insisted that AD-X2 was nothing but a mixture of epsom salts (sodium sulfate) and glaubers salts (magnesium sulfate). Ritchie rebutted this testimony by claiming that the words "slightly basic" in slightly basic magnesium sulfate were the key to satisfactory performance.

Dr. Astin testified that exhaustive NBS tests had revealed AD-X2's contents down to five parts per million. He confirmed that the powder was a mixture of sodium and magnesium sulfates. But according to NBS, "slightly basic" meant that the magnesium sulfate was impure, and Ritchie's trace elements were merely the usual impurities found in commercial salt.

On Previous Reports

The committee tried to clarify the conflicting reports that had been issued on the powder. Testimony showed that a Massachusetts Institute of Technology report—previously interpreted as substantiating Ritchie's claims—did not reach any definitive conclusion.

Harold C. Weber, an MIT professor in chemical engineering admitted that the MIT tests were inadequate to prove or disprove the merits of the additive.

On Performance

The most divergent opinions were heard on the performance of AD-X2. Ritchie, supported by several of his distributors, described the wonders his powder had worked at the U. S. Submarine Base in Connecticut, and at several large plants.

NBS, on the other hand, stuck to its original opinion: there was no proof that AD-X2 had been responsible for any improvements in battery life. Astin reported on a test conducted at the Bureau last year that Ritchie "guaranteed would demonstrate the merits of the powder". A group of judges that included the inventor were unable to tell any difference between treated and untreated cells.

Senator Thye, the commitee chairman, said that orders from substantial companies for AD-X2 had impressed him more than any testimony. He asked Dr. Astin to explain industry's continued use of the product.

The Bureau director answered this way: "If you take an aspirin for a cold and then feel better the next day, you don't know if the aspirin was responsible or not. You might have felt as well without the aspirin. It's the same with AD-X2."

That was too much for the committee. They decided to drop the whole thing, leaving any decision up to the National Academy of Sciences which has appointed an impartial group of scientists to conduct exhaustive tests.

NSF TRAVEL GRANTS

NATIONAL SCIENCE FOUNDATION, charged with encouraging scientific research with financial assistance, will see that the United States has adequate representation at six international technical meetings next year. NSF is accepting applications for a limited number of grants that will help pay travel expenses to these meetings:

- International Union of Pure and Applied Physics; London, England; July 6 to 10, 1954.
- World Power Conference; Rio de Janeiro, Brazil; July 25 to August 8, 1954.
- International Union of Theoretical and Applied Mechanics; Brussels, Belgium; July 28 to August 2, 1954.
- International Mathematical Congress and International Mathematical Union; Amsterdam and The Hague, Netherlands; August 30 to September 9, 1954.
- International Union of Geodesy and Geophysics; Rome, Italy; September 16, 1954.
- International Scientific Radio Union; Amsterdam, Netherlands; September 1954.

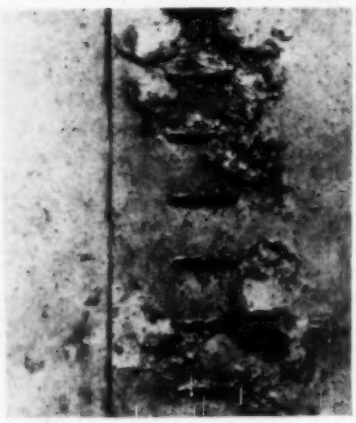
Applications for the first three meetings must reach NSF, Washington 25, D. C. by the first of December; applications for the last three, by January first.

Exposed to Marine Atmosphere

Unclad aluminum alloy 24S-T3.

Clad aluminum alloy 24S-T3.

Exposed to Salt Water Wettings



Serious corrosion of unclad alloy.

Minor weathering of clad alloy.

MORE CORROSION DATA—

FOR THE CONTINUOUS FIGHT against salt water corrosion, the National Bureau of Standards supplied some additional ammunition recently. After exposing to marine conditions sheets of unclad and aluminum clad 24S-T3 aluminum alloy (the high strength material containing 4½ percent copper and 1½ percent magnesium) stapled together with galvanized steel wire, NBS' Corrosion Laboratory reported:

1) Either type of sheet performed satisfactorily when exposed only to marine atmospheres.

2) Only the alclad alloys was satisfactory when the sheet was subject to wetting by sea water.

NBS ran the tests at the request of other government agencies because the use of galvanized-steel-wire stitching, or stapling, to join aluminum sheets is increasing. The biggest user is the aviation industry: to fabricate non-load bearing walls and partitions in the airplane's interiors. Non-aircraft applications include thermally insulated wall panels and interior panels of automobiles and busses.

During the 37 month exposure, scientists checked the panels repeatedly, making both macroscopic and microscopic observations. Typical of their findings:

• Unclad panels exposed to salt water deteriorated rapidly. After two months, the zinc coating on the steel staples was white with corrosion. After six months the zinc was completely eaten away; the staples were covered with dark adherent rust; and underneath the staples, the sheets were cracked by stress corrosion (the cracking having started at the faying surfaces). At the end of the 37 month exposure, the staples were badly pitted and rusted, and the sheets suffered severe crevice corrosion in the area of the staples—as well as stress corrosion cracking.

• The alclad sheets, on the other hand, stood up much better. Even after 37 months some of the zinc-iron alloying layers were left on the staples. The underlying steel had barely begun to pit. There was little or no crevice corrosion and there was stress corrosion in only one spot of one panel.

• When exposed only to marine atmospheres, neither sheet showed any appreciable effect even after the full exposure. None of the staples were significantly pitted and each retained some of the zinc and zinc-iron layers. Crevice corrosion was mild, but sufficient for the Bureau to recommend sheets exposed to such weathering should be covered with protective coatings for maximum life.

PACKAGED PROCESS CONTROLS

TO AUTOMATICALLY CONTROL various industrial process operations, Minneapolis-Honeywell Regulator Company has developed a series of packaged units, designed to take advantage of the similarity of operations in several industries. For example, the company claims that a batch cooking operation is basically the same in a textile, chemical or pharmaceutical plant.

Each unit, engineered for a specific process operation, will include recording and controlling instruments, measuring and control elements, and related accessories. One big advantage of such units: processors will be able to select a system on the basis of over-all function, instead of employing a time-consuming consideration of the characteristics of individual control elements.

Eventually the matched control units will cover all industries, ranging from ceramics and chemicals to textiles and utilities where there is little variation in control elements.

RARE METALS

WASHINGTON—Atomic energy research continues to turn up new applications for unfamiliar metals. Currently heading the list: hafnium and the rare earths. Metallurgists studying these materials predict that design engineers will be using them widely in the next few years.

Because of its unique properties, hafnium promises to become one of the most important metals of the future. Excellent corrosion resistance and ability to withstand excessive heat particularly have awed scientists. In a mixed carbide with tantalum, hafnium forms an alloy that has the highest melting point of anything man has tested.

Atomic Energy Commission scientists became interested in hafnium because of its close association with zirconium, the corrosion resistant, titanium-like metal that doesn't absorb neutrons. Hafnium is always present in zirconium ores. And although its chemical and physical properties are like zirconium, its nuclear characteristics are just opposite. Zirconium is a poor neutron absorber; hafnium is an excellent one.

That property introduces many atomic energy uses for the metal: control rods in piles (introduction of hafnium rods to absorb neutrons and slow down the fission reaction), containers for radioactive materials that are strong neutron emitters, shielding, etc.

Right now lack of production facilities and high costs block widespread use of hafnium. The ore runs about two to five percent of zirconium ore. With production of that metal only 75 pounds last year, there was barely enough hafnium available for further studies of its properties.

In addition hafnium requires additional purification processes after it has been separated from zirconium. That makes the metal even more expensive than zirconium which costs about fifteen dollars a pound.

Rare Earths

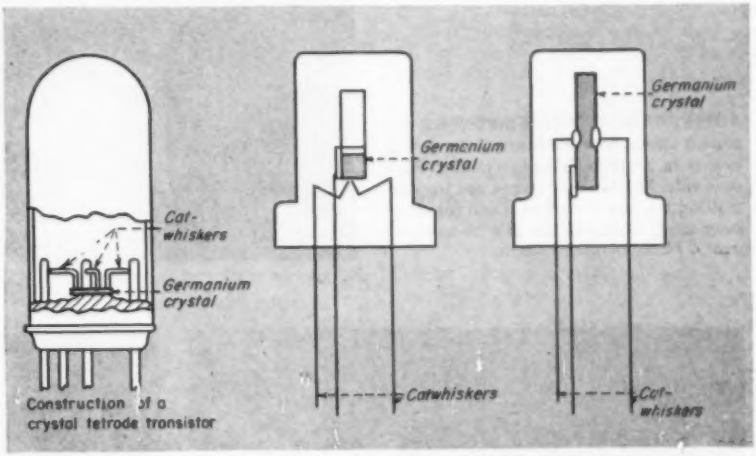
Metallurgists first became interested in the rare earths when they were successfully alloyed with magnesium. In later experiments they were added to both ductile iron and steel, improving ductility, impact strength and weldability. British scientists have added them to cast iron to turn out a substitute for steel.

Until recently, Misch metal, an alloy of all the rare earths and cerium in the percentages which are found in nature, has been the alloying agent. Now scientists are reporting uses for the individual rare earth metals and their oxides.

Typical of the interest is that surrounding gadolinium. This was merely another name in the periodic table of elements until scientists discovered it has the highest neutron absorption coefficient of any metal—including hafnium. Little else about the properties of the individual rare earths has leaked out from AEC labs.

At its Ames (Iowa) Laboratory, AEC has pioneered the development of a technique for separating the rare earths. They finally perfected an ion exchange process that separates laboratory-size quantities of the earths. Today the technique is too expensive for commercial operation. But Ames personnel are now working on modifications that will make it economically feasible.

Raw materials for the process are abundant. Most important sources: 1) by-products of the fission process in plutonium reactors; 2) heavy deposits of Monazite sands recently uncovered in Idaho; and 3) large deposits of Bastnastite discovered in New Mexico and California now being mined.



CONSTRUCTION of new crystal tetrode transistor compared to older three element point contact (center) and junction type (right) units.

NEW TRANSISTORS

TO THE ELECTRONICS INDUSTRY a transistor has meant a three-element, semi-conductor device that would replace vacuum tube triodes in certain applications. Last month Sylvania Electric Products, Inc. broadened the definition. They announced the successful development of tetrode and pentode transistors.

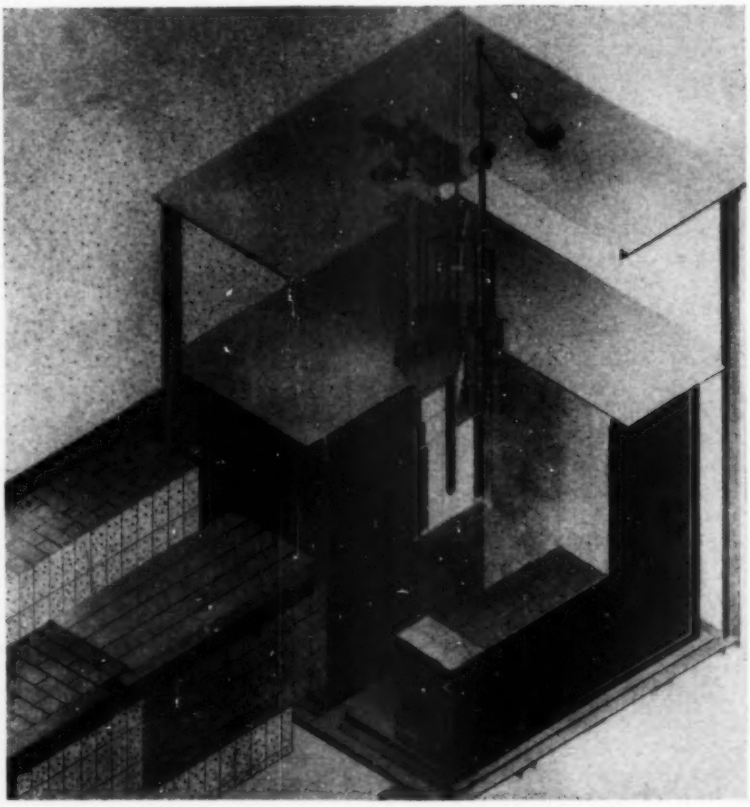
Development work has progressed so far with the four element units that Sylvania expects to offer them commercially this month. The five-element units are still being tested; they'll be available by the end of the year if everything goes according to schedule.

Like their smaller counterparts—the junction and point contact transistor—the new devices use semi-conducting germanium crystals. But where the triode transistor has two cats whiskers in contact with the germanium crystal, the tetrode has three; the pentode, four.

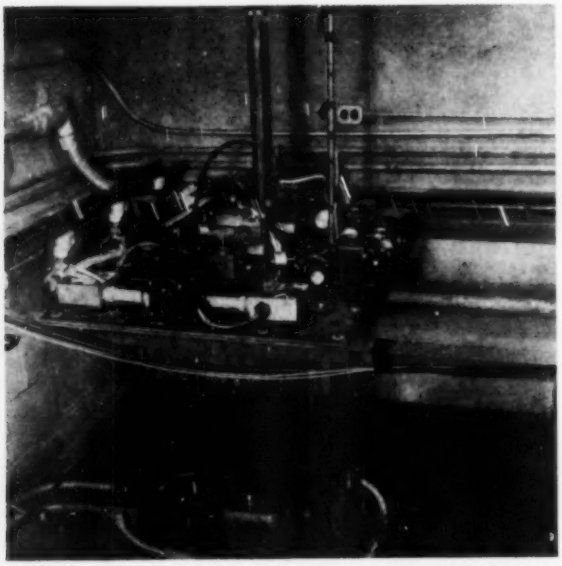
Sylvania expects that their new semiconductor units will broaden the application of transistors. Since the new transistors can replace older types on a one-for-two or one-for-three basis, they will permit the building of even more compact electronic equipment.

THE NEWS IN PICTURES

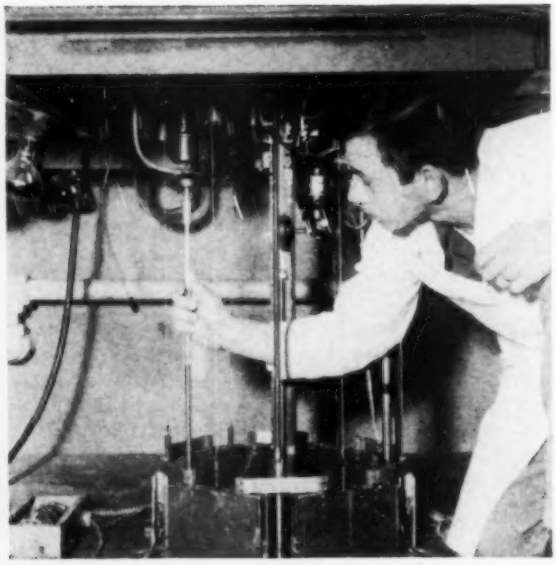
LAST MAY, General Electric revealed that they had built a "pint-sized" atomic pile for research purposes. Now the Atomic Energy Commission has permitted the company to release these pictures of the unit which takes up no more space than a bank of four ordinary filing cabinets. One of the few close-ups of a nuclear pile that AEC has allowed, these photos show some of the accessory equipment that is required in atomic energy installations, even with a low power unit such as this. A unique feature of the GE pile is an internal "thermal column" where the neutron flux is much greater than in the fuel region surrounding it. Parts to be bombarded by neutrons are placed in this column.



ARTIST'S DRAWING of the thermal test reactor shows how the heart of the unit is buried in graphite blocks, five feet thick on a side. Mechanisms on top are for controlling the rate of fuel feed and for dropping safety rods into the pile in an emergency. Note thermal column.



CLOSE-UP of the mechanisms that control the feed of fuel rods and safety rods into the reactor. Since humans cannot get close to the pile while it is in operation, fuel feed system depends on mechanical components and servo equipment. Control is exerted by lowering cadmium rods and sheets with the enriched fuel.



THIS TECHNICIAN is checking the emergency "drop" system that operates the safety rods. The rods, made of cadmium that absorbs neutrons, are held in place by electromagnets. If the pile gets overactive, the rods can be dropped instantly to stop the reaction. This is the key protective device on all reactors.

NEW COMPUTER MEMORIES

WITH COMPUTERS now an accepted adjunct to the engineering department, the men who build electronic brains are concentrating on improving the devices' weakest part—the computer memory. The two latest developments in the computer field are memories:

- The Oak Ridge Automatic Computer, Logical Engine (ORACLE) has an internal memory system with the greatest capacity of any high-speed, general purpose, digital computer ever built.
- Radio Corporation of America has developed a high speed electronic memory that can store 10,000 digits at any given instant.

ORACLE, built at a cost of $350,000 by the staff of Argonne and Oak Ridge National Laboratories, boasts three features that makes it superior to other digital devices: its internal memory system, its remote-controlled auxiliary memory system (magnetic tape), and its speed of operation.

The internal memory can receive, retain and process as many as 2,048 words (a word is equivalent to one twelve-digit decimal number)—twice the number handled by other computers of this type. The memory unit consists of 80 three-inch cathode ray tubes that store information in the form of electrical charges on the face of the tube.

An amplifier detects these charges and produces a signal that is transferred to the arithmetic unit or is used to regenerate the information in the memory. This form of memory requires periodic refreshing. In the ORACLE, refreshing takes place automatically about 65 times per second.

The magnetic tape auxiliary system provides for the storage of four million words.

Because it can multiply 12-digit numbers by 12-digit numbers in less than 1/2,000 of a second, ORACLE is rated by many as the fastest worker of the general purpose computers. It can add two 12-digit numbers in about 5/1,000,000 of a second.

RCA's new memory tries to combine high speed operation with vast storage space. Basically it consists of 10,000 tiny ring-shaped magnets woven on thin wire mesh. At each wire intersection there is a magnetic core with a vertical wire and horizontal wire through it.

The magnetic material is such that when an electric current of a certain intensity runs through the two intersection wires, a core will switch its magnetic polarity.

MORE TITANIUM PRODUCTION

WASHINGTON — U. S. titanium sponge production got more government encouragement last month. The Defense Materials Procurement Agency announced the signing of a contract with Cramet Inc.—subsidiary of Crane Corporation, Chicago, Ill.—which will boost annual production by 6,000 tons.

Under terms of the agreement, the government will loan the Chicago company up to $24,950,000 for construction and equipment; Cramet will pay back the loan with interest as production proceeds.

Under current plans, the plant is scheduled for full production by 1956. Crane has agreed to produce 30,000 tons of titanium in a five year period; the government has guaranteed to buy 6,000 tons of their production during the same length of time.

Previously the government was aiming for an annual production of 22,000 tons by 1956. This newest facility along with expansion of other facilities has boosted goals to 30,000 tons. Previously the government had signed contracts with two other producers: Titanium Metals Corporation and Dupont. Both call for large production over a five-year period—18,000 tons for Titanium Metals and 13,500 for the other.

All three companies have, or will have, facilities that use the Kroll magnesium reduction process of producing titanium sponge. All the contracts have escape clauses that permit terminating the agreement if someone comes up with a low cost process that would obsolete Kroll equipment.

Right now the government isn't worried about the obsolescent factor. DMPA officials say that even if a better process is developed, they doubt if plants could come into full scale production before the termination of present contracts. Sponge making, they say, is a tricky operation.

DRAFTSMEN at Ace-Central States Machine Tool Company are using a vertical wall drafting machine to make full-scale drawings of heavy equipment for automotive, construction, and aircraft industries. The company claims that their people prefer the vertical machine to a horizontal one when working on king-sized prints.

PLASTIC DESIGN PIRACY

ONE OF THE BIG ADVANTAGES of using plastics for housewares is the ease with which a producer can tool up and get into large scale production. Lately this advantage has been boomeranging on manufacturers. It has led to an epidemic of design piracy that is plaguing reputable fabricators.

The Society of the Plastics Industry is studying what legal redress members can seek from such unethical competition. SPI reports the copying has gone to such extremes that pirates are even using legitimate manufacturers' products for patterns to form their copied molds.

There appears to be only two avenues of approach to preventing design stealing: One is a voluntary elimination of the practice on an industry-wide basis, put together under the auspices of the Federal Trade Commission. The other answer is to invoke the copyright law. A recent ruling in a California Court held that a copyright granted to a complainant on a design was valid and anyone who minutely copied the design violated the copyright protection.

GOOD HEADS . . . GOOD THREADS . . . GOOD BOLTS

If you are looking for a good line of standard bolts, one which combines quality and variety, choose Bethlehem Bolts.

Bethlehem machine, carriage and lag bolts are well made from top-quality steel. They have good, strong heads and smooth-running threads, and come in all types and sizes. We also manufacture a full line of turnbuckles, clevises, rivets, spikes, washers and nuts.

Bethlehem Bolts are good, dependable bolts—good bolts in every way.

BETHLEHEM STEEL

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Bethlehem supplies every type of Fastener

Radiation Characteristics of Metals

JOSEPH POGGIE
Republic Aviation Corporation

THESE DATA show the relative effects of surface texture and composition on the radiation characteristics of different metals at elevated temperature. These characteristics are expressed by their percent emissivity which equals:

$$\frac{\textit{Radiation Intensity of Specimen}}{\textit{Radiation Intensity of a Black Body}}$$

The results can be summarized as follows:

1. Examination of test results and visual observation during tests indicate that the reflection characteristics of the tested materials in the infra red region are modified by oxidation and surface texture. Color appears to have no detectable effect.

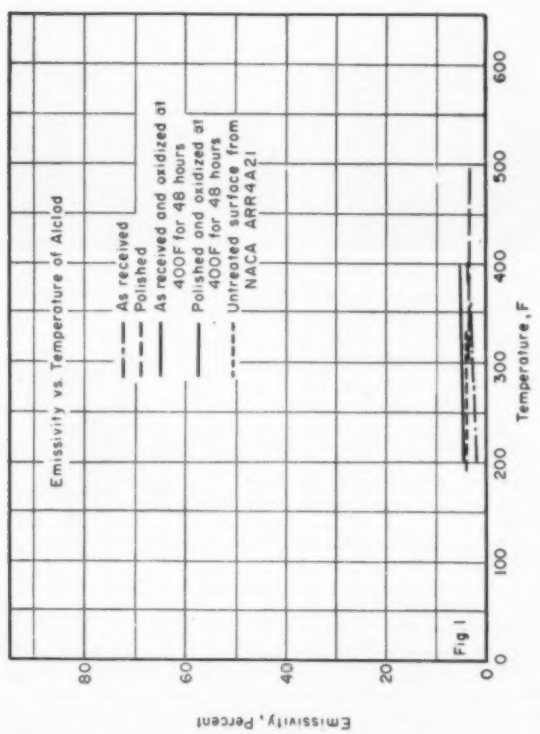
2. Alclad: Polishing has little or no effect on alclad, probably due to the fact that, when received from stock, alclad already has a high polish. Prolonged exposure at 400 F resulted in a marked increase in emissivity of both polished and unpolished specimens (Fig. 1).

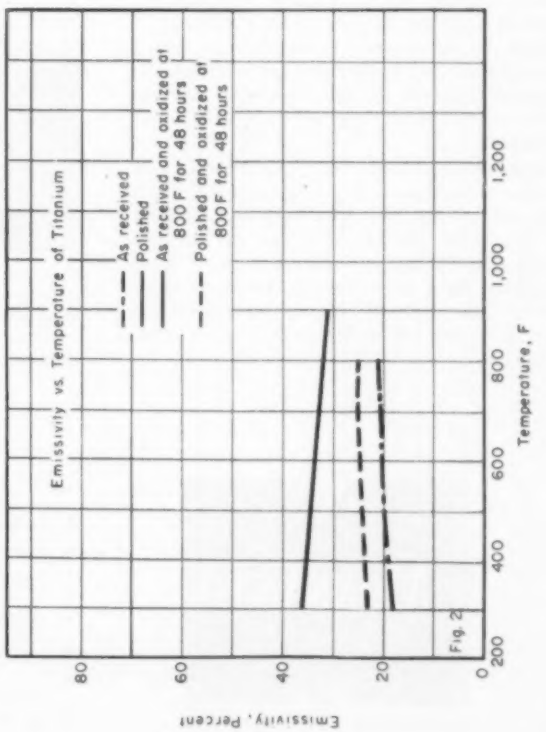
3. Titanium: Emissivity of polished and unpolished titanium (oxidized) was equal. After being subjected to 800F for 48 hours, the value of emissivity of the unpolished surface was from 5 to 12 percent higher than the polished surface.

4. Stainless Steel: Polishing caused a substantial decrease in the emissivity. Prolonged exposure of 800F had no effect. Emission increased, however, when the specimens were oxidized at 1,200F.

5. Nickel Alloys: Inconel, Inconel X and Monel exhibited marked increases in emission when exposed to 1,200F for 48 hours. This was true of both polished and unpolished surfaces.

(continued on page 207)





NEW PLASTIC MATERIALS ADD PROPERTIES NATURE FORGOT

Look to today's new materials for help in putting new properties into your product

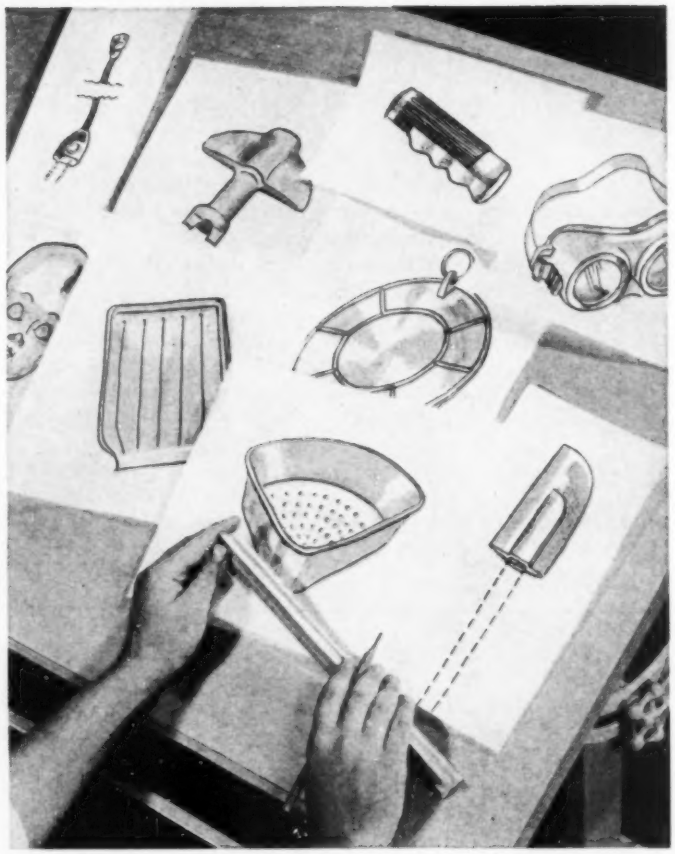
What properties would you like to add to your product? Flexibility . . . toughness . . . chemical resistance . . . smarter appearance . . . color?

For many manufacturers (and you may be one), better, faster selling, more versatile products will be a reality tomorrow . . . because of new, improved materials uncovered by Monsanto research today.

For example: Monsanto recently developed a new technique for molding its Opalon vinyl resin . . . which greatly widens the range of applications for injection molding vinyl chloride. Typical of the vast research daily devoted to plastic materials, processes and applications, this latest development in the injection molding of Opalon dry blend vinyl resin opens new design opportunities for manufacturers of electrical equipment, flexible fittings, appliances, sporting goods, housewares, toys and many industrial products.

Perhaps you, too, have a use for Opalon—or another Monsanto plastic—in your present products, or ones still on the drawing board calling for properties possible with one of the new plastics. You'll find answers to many of your questions about these new materials in Monsanto's latest report to management. Send for your *free* copy today; the coupon is for your convenience.

Opalon: Reg. U. S. Pat. Off.

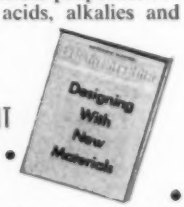


For products such as automotive and refrigeration parts, sporting goods, toys, housewares, etc., Monsanto's Opalon vinyl plastic delivers flexibility ranging from soft to semi-rigid . . . outstanding electrical properties . . . resistance to abrasion, moisture, oxidation, most acids, alkalies and common solvents . . . and a wide range of color.

MONSANTO

SERVING INDUSTRY . . . WHICH SERVES MANKIND

FREE—REPORT TO MANAGEMENT



MONSANTO CHEMICAL COMPANY, Plastics Division, Room 2133
Springfield 2, Mass.

Please send me your new management report on new materials aiding design.

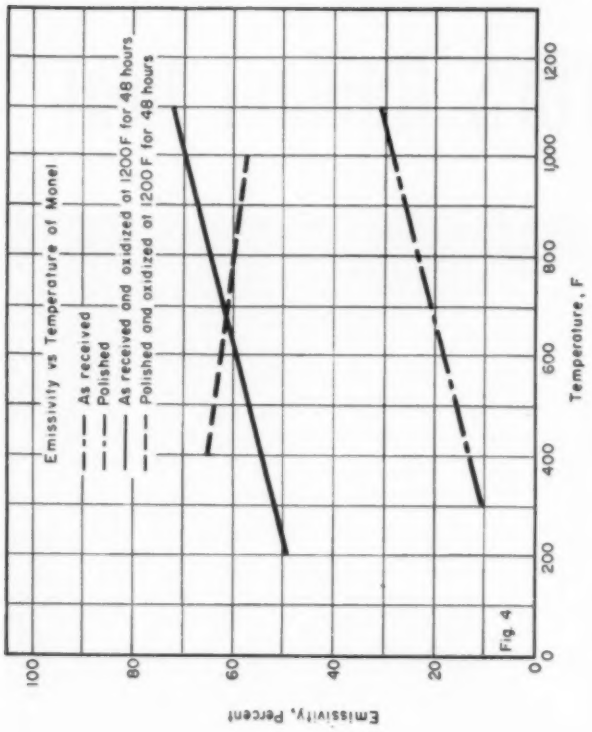
Name & Title _____

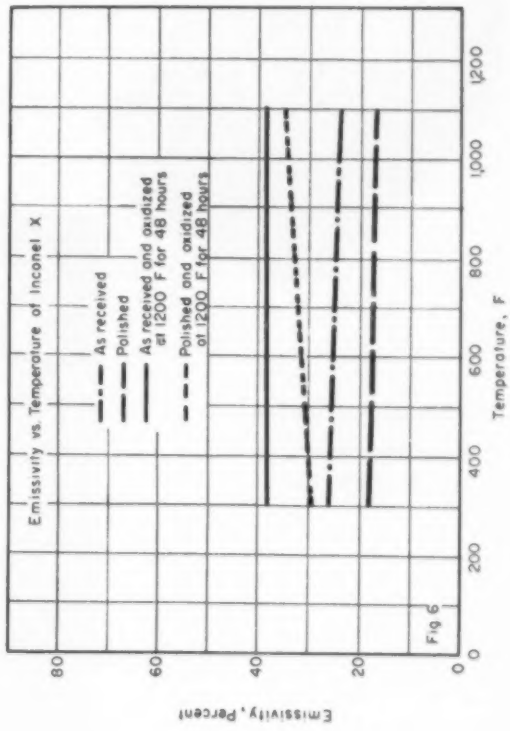
Company _____

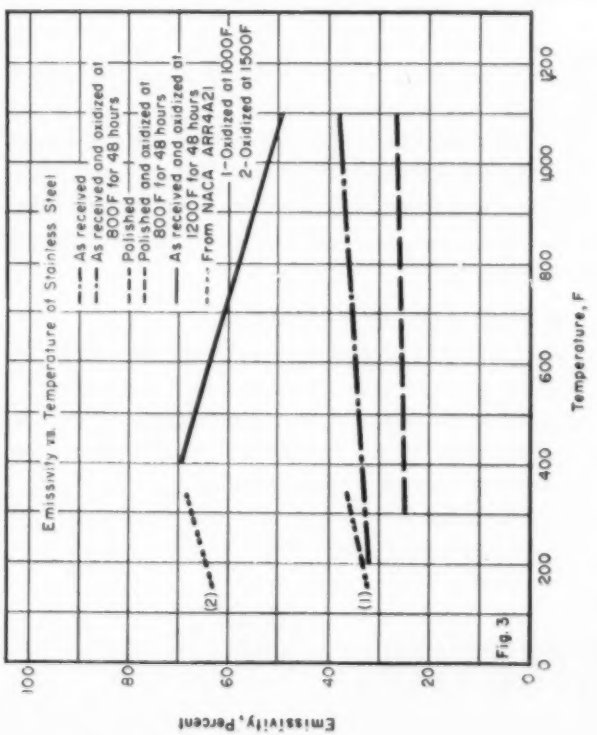
Address _____

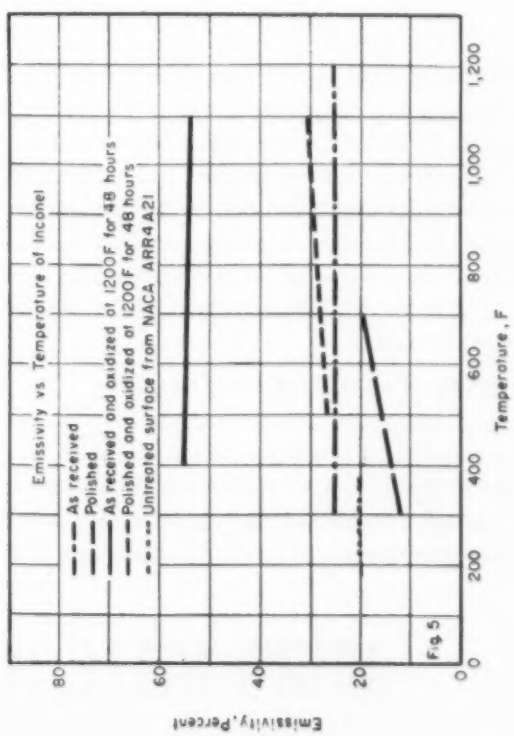
City, Zone, State _____

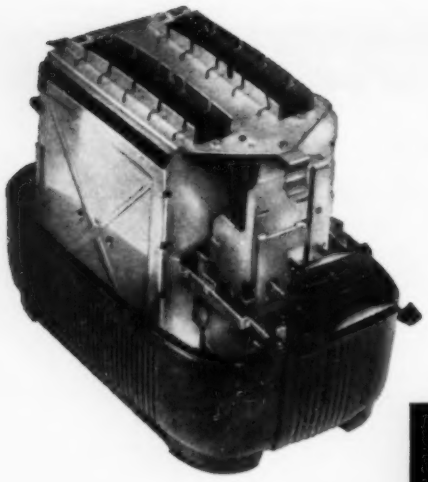
Radiation Characteristics of Metals (continued)


Emissivity vs Temperature of Monel
As received
Polished
As received and oxidized at 1200F for 48 hours
Polished and oxidized at 1200 F for 48 hours
Fig. 4
Emissivity, Percent
Temperature, F

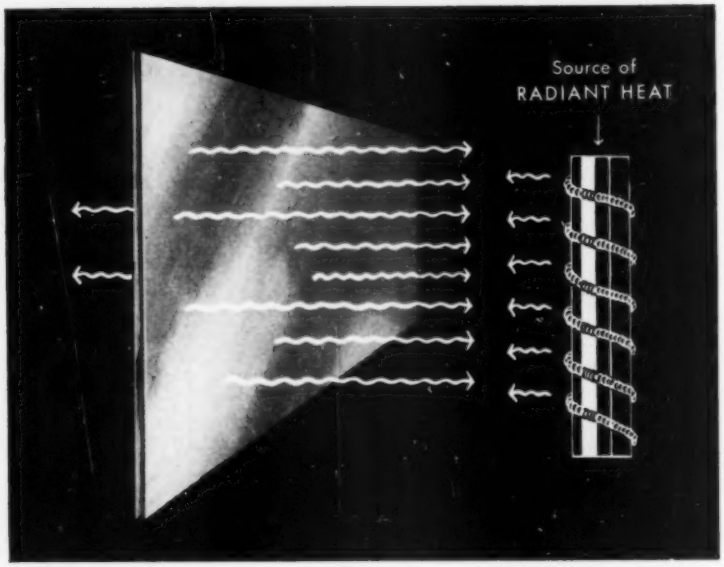

Emissivity vs. Temperature of Inconel X
As received
Polished
As received and oxidized at 1200 F for 48 hours
Polished and oxidized at 1200 F for 48 hours
Fig 6
Emissivity, Percent
Temperature, F




Emissivity vs. Temperature of Inconel
As received
Polished
As received and oxidized at 1200F for 48 hours
Polished and oxidized at 1200F for 48 hours
Untreated surface from NACA ARR4A21
Fig. 5
Emissivity, Percent
Temperature, F



This Steel STOPS Radiant Heat



This ALUMINIZED Steel interior of a toaster keeps the inside hot, the outside cool.

Armco ALUMINIZED* Steel is an effective heat *barrier* because it is an excellent heat *reflector*. Up to about 900 F, it reflects more than 80 per cent of the radiant heat thrown against it. Less than 20 per cent goes through this hot-dip aluminum-coated steel. That's why it raises the heating efficiency of infra-red ovens, ranges and other gas and electric appliances. It *contains* rather than dissipates the radiant heat.

ENDURES SCALING TEMPERATURES

Besides serving as a reflector of heat, Armco ALUMINIZED Steel is widely used where high temperatures would cause other low-carbon steels to fail through progressive scaling. ALUMINIZED will withstand temperatures up to approximately 900 F without discoloration, and up to about 1250 F without destructive scaling.

For this reason a prominent independent research laboratory has rated Armco ALUMINIZED Steel next to stainless steel for endurance in combustion chambers and burner rings of gas-fired furnaces.

A FLAT-ROLLED PRODUCT

Armco ALUMINIZED Steel is made in sheets and coils 12 through 28 gage in thickness and up to 36 and 48 inches in width depending on gage. For more information on this versatile material, write for the booklet, "Armco ALUMINIZED Steel".

For other Armco products see our catalog in Sweet's Product Design File.

ARMCO STEEL CORPORATION

4463 CURTIS ST., MIDDLETOWN, O. • EXPORT: THE ARMCO INTERNATIONAL CORPORATION

ARMCO

® U.S. PATENT OFFICE

Strength-Weight Ratios of Hollow Steel Shafts

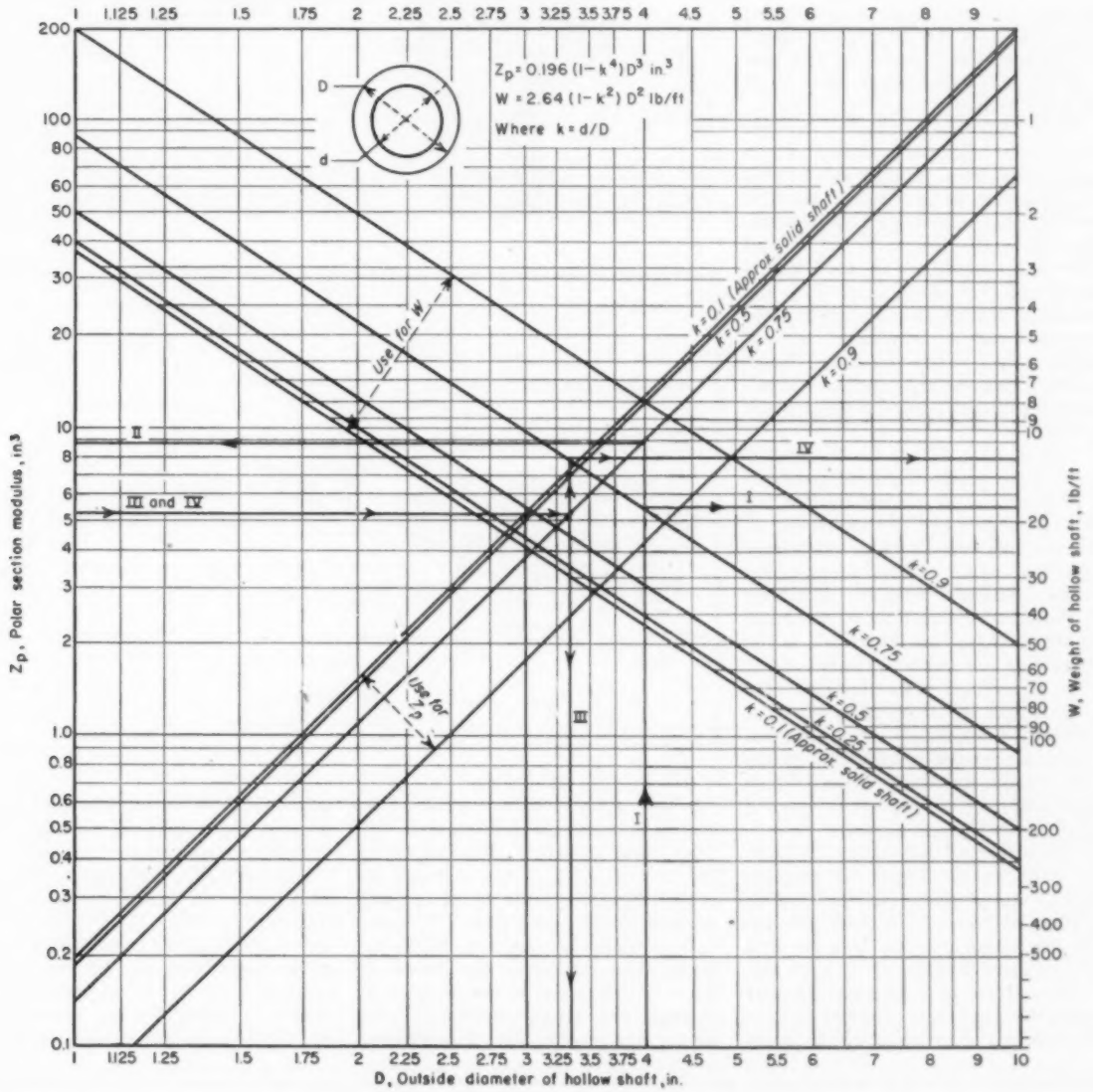
HANS W. SMITH

THIS CHART simplifies calculating of the weight per foot and polar section modulus of hollow shafts subjected to torsion. It can also be used for solid shafts with negligible error and for comparing strength-weight ratios of solid to hollow shafts. The equations used in its derivation are shown on the curve.

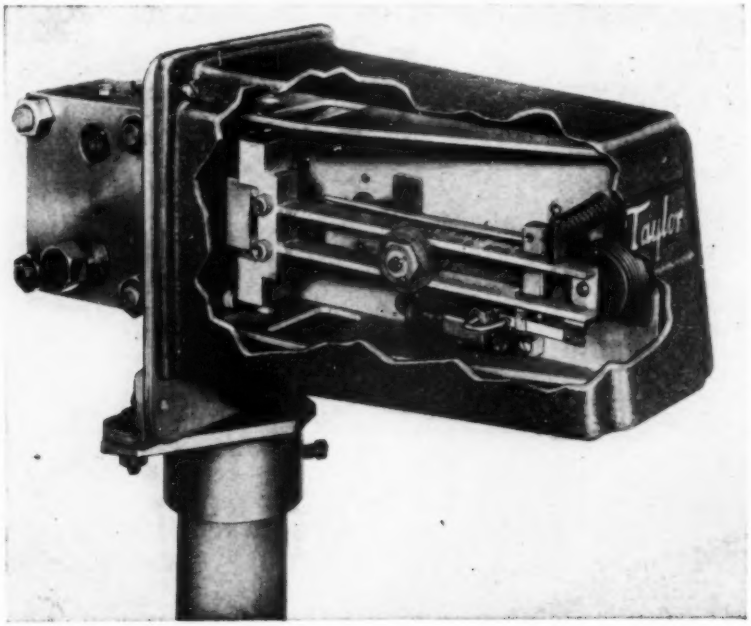
EXAMPLE 1. Given: ID = 3 in.; OD = 4 in. Since $R = 0.75$, Line I shows W = 19 lb/ft. Line II gives $Z_p = 8.8$ in.^{3}

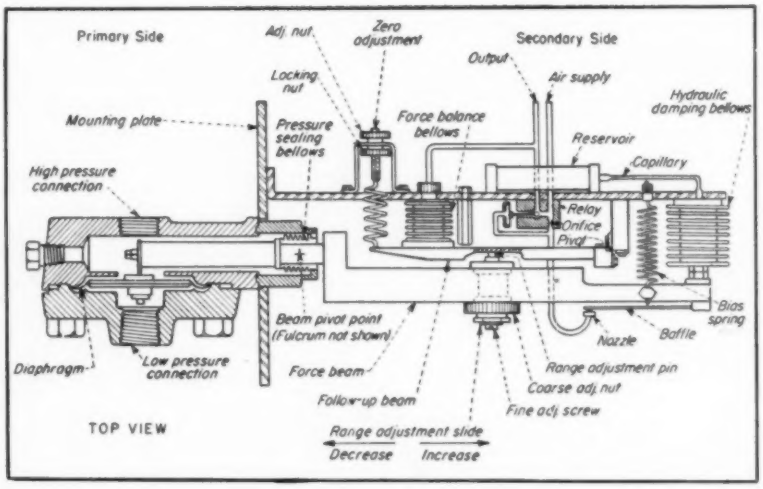
EXAMPLE 2. To transmit a given torque, a solid shaft with a dia of 3 in. is required. Z_p for this shaft is 5.3 in.^{3} and $W = 24$ lb./ ft.

Since the only condition required of a hollow shaft that can carry the same torque is that it have an equivalent value of Z_p, there are an infinite number of solutions. Lines III and IV indicate that one is: $R = 0.75$, $D = 3.41$ in., $d = 2.55$ in., W for this shaft is 14 lb./ft.



New Transmitter Simplifies Flow Measurement





Designed to be the answer to the problem of close-coupled fluid flow measurement, liquid level, or any other installation requiring differential pressure measurement and transmission, this force-balance transmitter converts differential pressure into an equivalent 3 to 15 psi output, and can be used to measure flow of liquid, steam or gas; liquid level, or specific gravity. Speed of response is one second for 63.2 percent of full scale change with 50 ft of $\frac{1}{4}$ in. tubing.

This Transaire transmitter has two basic units: (1) the primary, which senses differential pressure and consists of a two-part, forged steel or stainless steel housing enclosing a Teflon-coated, glass-fabric diaphragm to permit full over-range protection of 1500 psi to either side of diaphragm; (2) the secondary unit which transmits the proportional output air pressure and includes a heavy-duty pneumatic force-balance transmitting system. Maximum diaphragm operating temperature is 300F.

The primary side of the transmitter receives the process fluid and produces a deflecting force proportional to the differential pressure. The secondary or transmitting side develops an opposing force which is also proportional to the differential pressure. As shown in the cross-sectional view, the beam on which these two forces act, is the connecting link between the two sides. The separating plate between the primary and secondary units serves as a means for mounting the instrument.

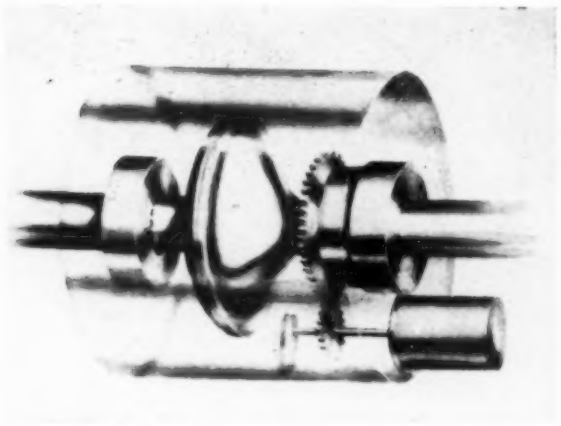
The diaphragm is connected to the force beam, and any motion of this beam about its pivot point is opposed by the force balance bellows.

The secondary side of the transmitter develops an output air pressure directly proportional to the process differential pressure. At zero differential the output pressure is 3 psi, and at maximum differential it is 15 psi.

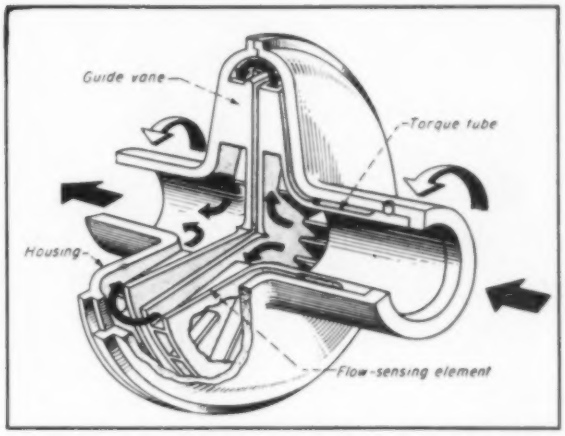
An increase in differential pressure across the diaphragm produces a movement of the force beam which carries the baffle away from the nozzle. This results in a decreased pressure in the relay valve chamber. The output of the reverse acting relay increases to restore the force beam to its original position through the action of the force balance bellows and the follow-up beam. The motion of the follow-up beam is transferred to the force beam through the range adjustment pin. Range changing (a 10 to 1 continuous adjustment) is accomplished by positioning the range adjustment slide marked for the various ranges.

An hydraulic damping circuit has been made an integral part of the transmitting side. A damping bellows is attached to a point near the end of the force beam, and by means of a capillary tube it is connected to a reservoir vented to the atmosphere.

Taylor Instrument Co., Rochester 1, N. Y.



A sketch af the liquid mass flowmeter. Measurement is made of the torque necessary to give the flowing mass an acceleration. This torque is dependent only on the dimensions of the flowmeter, a rotaticnal speed, and the mass flow, eliminating any volumetric troubles.



As the torque is directly proportional to the mass flow and the speed of rotation, it is possible for the scale of the unit to be changed by changing the speed. Since the calibration is linear, a wide range of mass flow can be measured with a single point calibration.

Mass Rate Flowmeter Measures Gas, Liquid, Or Solids

In processes where solids are carried in a fluid stream, such as catalytic cracking plants, the true rate of total mass flow can be measured directly by an instrument that is capable of measuring the mass flow of any gas, liquid, solid, or mixture which can be made to fall through a pipe. This true mass rate flowmeter automatically accounts for any transients in the system, and direct reading measurements can be made in pounds per minute. Accuracy of measurement is completely independent of volume, temperature, pressure, viscosity, compressibility, or external accelerations.

Currently available flowmeters fall into five general categories: a constant-area variable-head type (orifice meter, venturi); an average flow velocity across a fixed area; a positive displacement type (flow-actuated free running turbine, gear pump driven by flow); a variable-area type (variable orifice, float in a tapered tube); an impact pressure type (nozzle directed at a fluted wheel). The manufacturers claim that these are all dependent on density, viscosity, volumetric flow rate, temperature, pressure, or compressibility of fluid, while the mass rate flowmeter is independent of these factors.

Basically, the mass rate of flow is measured by determining the moment necessary to give the mass Coriolis acceleration. Referring to the cutaway drawing of the flowmeter, it is shown that the fluid stream is forced out radially by its own velocity, and that the path of a given particle is a spiral because the sensing element and the flowmeter case is rotating. The particle now has an increasing tangential velocity which has been imparted to it by the flowmeter. To get this velocity change, the mass of the particle had to be accelerated. The reaction to the force producing this acceleration was exerted on the vane of the sensing element, which formed a torque about the axis of rotation and served to twist the torque tube. The measurement to be made is the amount of twist in the torque tube or the phase shift between the sensing element and rotating case.

The motor driving the flowmeter only supplys the bearing and seal friction, and the windage. As the sensing element rotates at the same speed as the case, there are no shear forces due to the viscosity involved. Also, the force produced is the product of the mass and the acceleration, so that pressure or temperature have no effect.

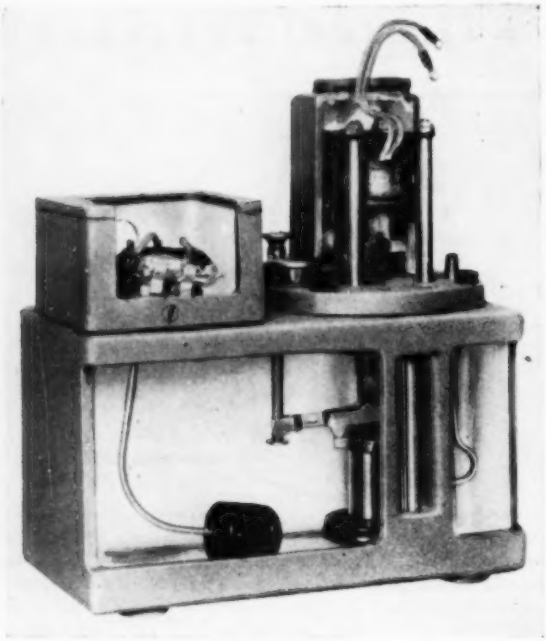
Other advantages of the unit are: (1) It will work on multiphase fluids such as mists, foams, slurries and emulsions, homogeneous fluids, aerated powders, or pieces falling by gravity; (2) It will read flow in either direction, and the output reverses when the flow reverses; (3) Permits accurate measurement on rapidly changing flows; (4) Makes measurements of the average valves of pulsating flows; (5) The scale factor can be shifted over a large range by changing the rotational speed; (5) The same scale factor applies to any material which can be made to flow through the meter; (7) It is unaffected by gravitational or other translational accelerations.

The flowmeter will measure and control the rate of flow in an industrial process, weigh the grain transfer between an elevator and a freight car, give a measure of gas line flow without variances caused by temperature and pressure, and meter exact weights of fluids or powders for packaging. With the addition of a proportioning unit, and two or more flowmeter units, it will control weight mixtures in chemical plants and for other processes.

Until flow rates and sizes of the units have been standardized, all flowmeters will be custom built for the job.

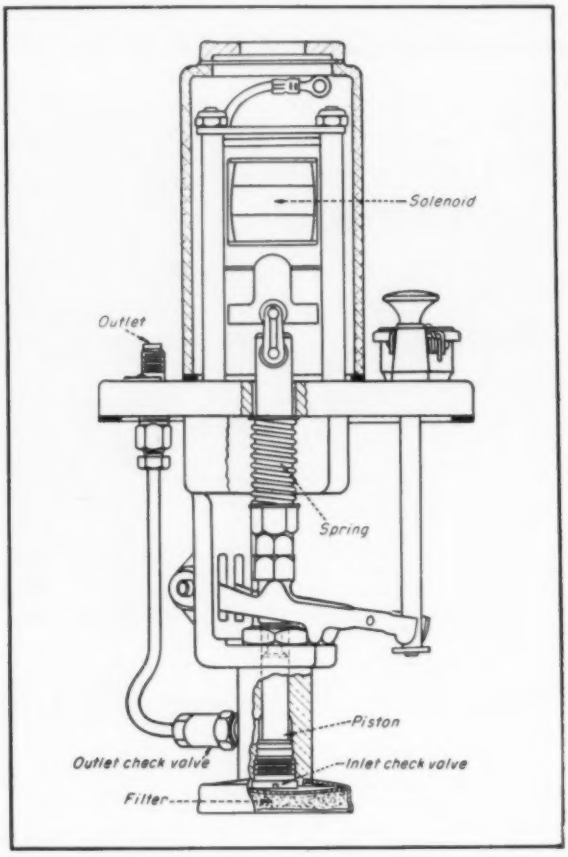
Control Engineering Corp.,
560 Providence Highway, Norwood, Mass.

CONTINUED ON PAGE 212



AVAILABLE AS AN EXTRA is a float-switch control that can actuate a visible or audible alarm when the oil supply is low. Then, if the supply is not replenished, the switch will shut off the machine, preventing damage to the bearings.

THE COMPLETE UNIT is available with a choice of two reservoirs, 3-pint or 6-pint capacity. No mechanical linkage to the lubricator is required, making it possible to mount the unit without reference to moving parts. It can be located anywhere.



Solenoid Operated Lubricating System

Automatic metered lubricating systems using a new solenoid-operated lubricator, can be applied to almost every type of machine and mounted in any location, with no connection to a moving element of the machine required.

Flexibility of control is one of the main features of the new lubricator, it can be actuated by switches, tripped by rotary or reciprocating motion, existing control circuits, electric timer controls, foot switches or push buttons. Because of this feature, the unit is adaptable to use on special machinery as well as standard models. The new lubricator can be used on machine tools, metal working machinery, packaging, bottling, printing, textile, and woodworking machinery, and special industrial machines.

Shown is the type "E" lubricator which delivers from 0.8cc (24 drops) to 0.2cc (6 drops) of oil per stroke; maximum frequency of operation is recommended at 4 strokes per minute. The solenoid is rated at 4 amp., 110 volts, a-c, and when energized, a pump piston is drawn up, bringing oil into a cylinder. When the current is interrupted, a spring moves the piston down, forcing oil through the system and meter units at each bearing.

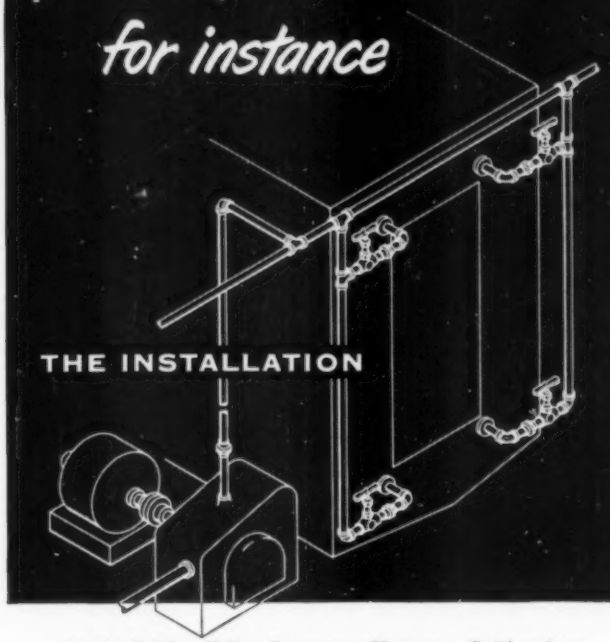
Temperature rise is within safe limits with the solenoid cover in place. The complete unit is available with a choice of two reservoirs, 3-pint or 6-pint capacity. The larger reservoir can be obtained with a double-contact float-switch control. This control actuates an audible or visible alarm when the oil reaches a low level, and then shuts off the entire machine if the warning is ignored.

Bijur Lubricating Corp., Rochelle Park, N. J.

ELECTRONIC SERVOSPEED SYSTEMS for the speed control of series or universal motors may be adapted to fractional and sub-fractional horsepower motors. A speed range of 100 to 1 is achieved with motors having a base speed of 5000 rpm or higher. Three wire motors may be controlled for one direction of rotation and 4-wire motors in either direction selectably by a small reverse switch. Straight motor and gear-motor types available from 1/100 to $\frac{1}{10}$ hp, 114v operation, and to $\frac{3}{4}$ hp for 220v. Electro-Devices, Inc., 6 Godwin Ave., Paterson, N. J.

CONTINUED ON PAGE 214

There's a Big difference–even in Small Valves ...on Spray Driers, for instance



At the Golden Valley Creamery, Newman, Calif., where Crane Bar Stock valves replaced original lead regulator valves on spray process milk driers. They handle hot milk from high pressure pumps, at 2000 to 3000 psi, at a temperature of 180° F.

VALVE SERVICE RATINGS

SUITABILITY: Couldn't be better

FEATURES: Solid bar stock construction

MAINTENANCE COST: None

SERVICE LIFE: Still top performance after 5 years

OPERATING RESULTS: No shutdowns for valve repairs

AVAILABILITY: Crane Catalog item – No. 222-SS

THE CASE HISTORY

The original equipment valves on these driers had a short life. They started failing quickly . . . couldn't be regulated . . . interrupting control of the process. Shutdowns for valve repairs were excessive; maintenance costs increased. The trouble was the stem threads were always stripping.

Not until all original valves were replaced with the sturdy, precision-made Crane 18-8 Mo Bar Stock valves, was the trouble completely stopped. That was more than 5 years ago. The Crane valves are still in the lines, holding down maintenance costs year after year, helping keep the plant at peak efficiency.

THE VALVE

You can see and feel the high quality of Crane Bar Stock valves. They're sturdy, compact and precision-crafted from solid steel, Exelloy, or 18-3 Mo, for cold working pressures up to 3000 psi. Sharply tapered disc gives closest flow regulation. Wide seating surfaces stay tight, resist wire drawing and cutting. You can't find a better valve for regulator leads, orifice meters, by-passes, and many similar services. Sizes up to 1-in. See your Crane Catalog or Crane Representative.

THE BETTER QUALITY...BIGGER VALUE LINE...IN BRASS, STEEL, IRON

CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

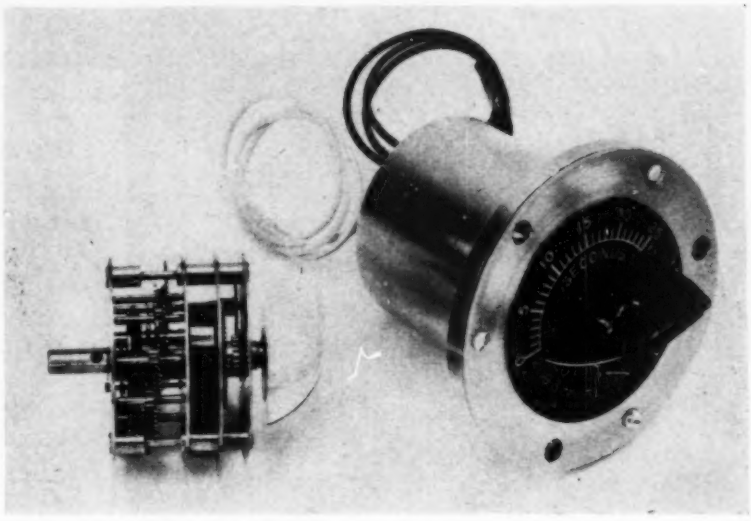
VALVES · FITTINGS · PIPE · PLUMBING · HEATING

Mechanically Wound Timing Device

The mechanically wound timing device shown in the illustration has been developed as a part of guided missile equipment, but is said to have many other commercial applications.

The function of the timer is to provide a time delay interval which is preset at any point between 1 to 30 seconds. The timing interval is started by a mechanical type inertia switch, which operates when an acceleration of 3 to 4 g's is obtained during missile launching. At the end of the preset time interval, the timer closes a switch in the missile electrical system.

The time delay unit shown has been designed for the following specifications: a temperature range from minus 58F to plus 176 F; altitude from 0 to 70,000 feet; it will withstand 30 g's in any axis with a maximum of 50 g's in the launching direction; time delay interval, 1 to 30 seconds, minus 0, plus 1 second. In addition, the timing unit is enclosed in a hermetically sealed case.



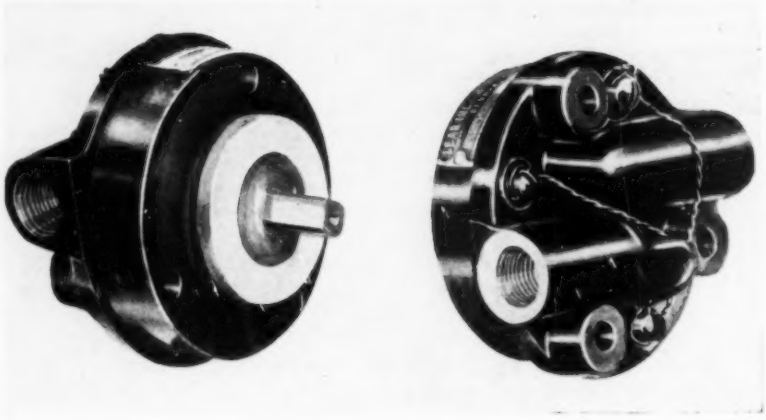
The time delay unit is shown in its case with a standard mechanically wound timer beside it for reference. The time delay unit is approximately $2\frac{1}{2}$ in. diameter at the flange with a $1\frac{3}{4}$ in. diameter on the case. Overall length is approximately $1\frac{3}{4}$ inches. Complete assembly weighs approximately 8 ounces.

Masco Products Co., 2119 Sepulveda Blvd., Los Angeles 25, Calif.

Small Size Oil Scavenge Pump

One of the advantages in using a positive displacement, rotary vane pump for scavenging lubricating oil from aircraft gas turbine engines is to obtain a simplified, more powerful pumping element, assembled in a small over-all envelope. Different in construction, the scavenge pump weighs only 0.5 pound and the same general advantage of the gas turbine engine applies to this model RD-9820 pump: fewer parts; high-speed operation; and smooth flow.

Representing the smallest of a series, this pump has a rated speed of 3800 rpm, an outlet pressure of 60 psi, and a flow of $\frac{1}{2}$ gal per minute pumping jet engine lube oil, grade 1005 with a power input of 0.15 hp maximum. The pumping element gives a non-pulsating discharge and strong self-priming suction at speeds of 350 to 4200 rpm.



Principal parts are steel material assembled in an aluminum alloy body: two sliding blades in a cross-slotted rotor revolve in the developed bore of the pump liner. Except for O-ring packing and attachments, no other parts are used. The developed bore of the liner controls sliding action of the blades, and lengthens the life of the blades and liner. The uniform displacement of the fluid results in a nonpulsating discharge. This pump can be used for complete scavenge-service at high altitudes, and is suitable for operation at —65 to 250F.

Companion scavenge-and-pressure oil pump combinations, designed specifically for gas turbine engines, contain duplication and triplication of the pumping elements.

Lear, Inc., Lear-Romec Div., Elyria, Ohio

CONTINUED ON PAGE 216

CONTINENTAL'S PROOF BOOK

J. M. CLARK

Purchasing Agent for the Budd Company at Detroit. Mr. Clark has held responsible positions in the Accounting and Purchasing Departments of the Budd Company for the past twenty-three years.

THE BUDD COMPANY

DETROIT 14 MICHIGAN

August 3, 1953

Continental Screw Company
New Bedford, Massachusetts

Gentlemen:

With reference to the Continental Screw Company, we must refute the adage, "Business and pleasure do not mix." It is a pleasure to do business with your organization. Not only the quality of your product, but the "personal touch" which you and your representatives show is greatly appreciated. You have always been most helpful with, and cognizant of, our requests.

It is hoped that "business as usual" will be the keynote in the years to come.

Very truly yours,

THE BUDD COMPANY

J. M. Clark
Purchasing Agent

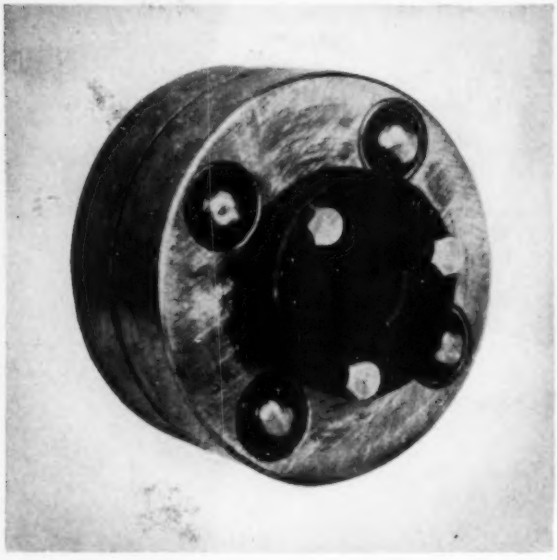
JMC:mp

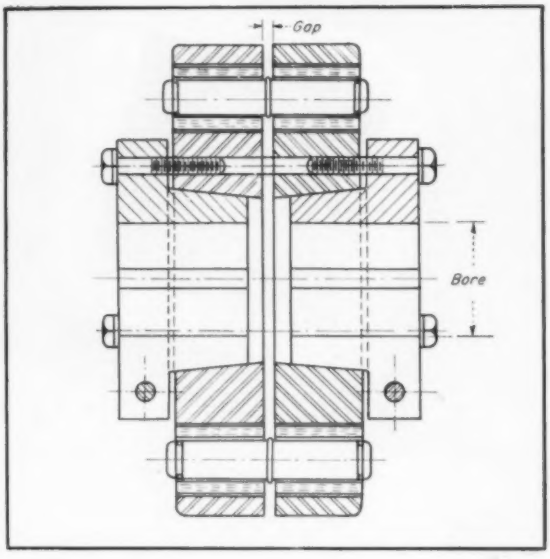
You too can count on Continental®

CONTINENTAL SCREW COMPANY INC. 1904

Manufacturers of HOLTITE Fastenings For Every Purpose

CONTINENTAL SCREW COMPANY, NEW BEDFORD, MASS., U.S.A.





Rubber Bushings In Coupling Permit Misalignment

Couplings which will allow both angular and parallel misalignment with a minimum of shaft pressure on the support bearings, are now available in a line known as the Silentbloc coupling, where no nuts or bolts are required for disassembly, and where operational noise is said to be greatly reduced. These features are accomplished by a new application of rubber bushings.

Instead of having one plate fitted with rubber bushings, and another with fixed pins, this new coupling uses two flanges fitted with encased rubber bushings, with free floating-pins connecting the two, and floating freely in the ID of the inner sleeve of the rubber bushings elements. The pins are held in position by means of snap rings on the pins, between the two flange members.

With this construction, the force applied to the rubber is a twisting or conical force. Each pin acts as a beam supported by a rubber bushing which can allow greater deflection at the end of the pin. The degree of stiffness of the bushing, and the unsupported length of the pin will determine the magnitude of deflection at the end of the pin. With each pin supported by the rubber at each end, the angular deflection between the driving and driven plates is obtained by the twisting action in the rubber and not by radial deflection.

The inner metal sleeve of the coupling is a steel sleeve lined with a fabric type of bearing material adhered to the metal. This lining material absorbs lubricants and acts as a self-lubricating bearing. Being non-metallic, it will not rattle, nor bind on the pin. Flanges are furnished in all standard sizes.

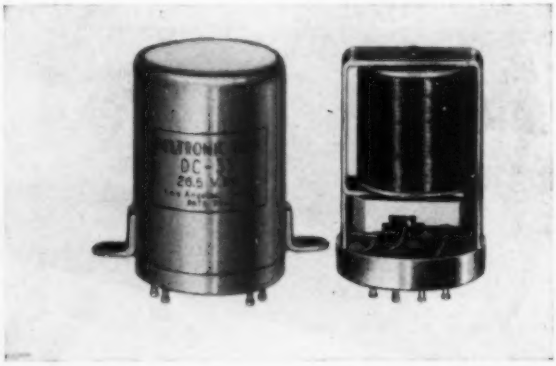
The Smith Power Transmission Co., Flexoid Coupling Div., 1545 E. 23rd St., Cleveland 14, Ohio

Ruggedized Miniature Relay

Although small (1.79 in. high, 1.188 in. in diameter), and weighing 3.62 oz, this hermetically sealed, double-pole double-throw d-c relay is said to exceed the service requirements of MIL-R-5757B specification. This positive action relay is designed to operate under 70 G acceleration and continuous vibration from 10 to 600 cps, without mechanical resonance, when mounted in each of three mutually perpendicular planes.

Ambient temperature range is —65 C to +125 C. The relay passes life tests of 100,000 cycle operations with contacts operating under rated load at 12 cycles per minute. Contact bounce of the unit is held to 250 microseconds, and contact rating is 2 amp with a 26.5 v d-c resistance load. Required input coil power is less than 0.325 watts.

Deltronic Corp., 9010 Bellanca Ave., Los Angeles 45, Calif.



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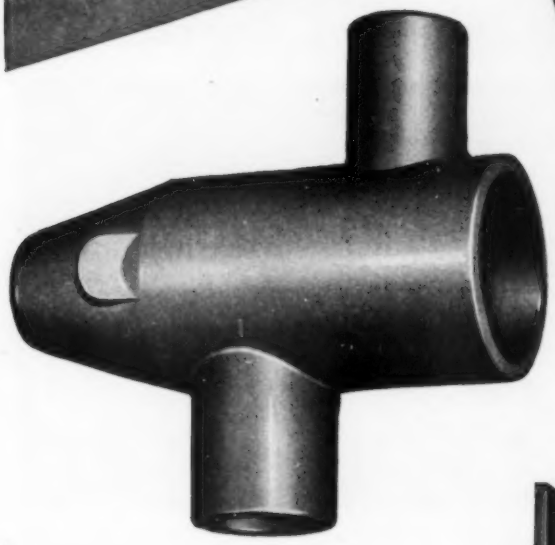
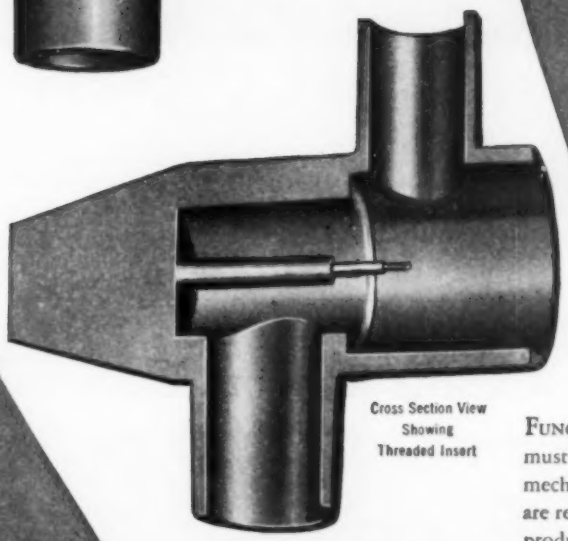
DESIGNING

for the DENTAL EQUIPMENT FIELD with MADISON-KIPP ZINC and ALUMINUM DIE CASTINGS





Cross Section View Showing Threaded Insert

Madison-Kipp aluminum die castings made for the Ohio Chemical & Surgical Equipment Co., a Division of Air Reduction Company, Incorporated, for their New Ohio Dental Analgesia Unit for administering TRIMAR.

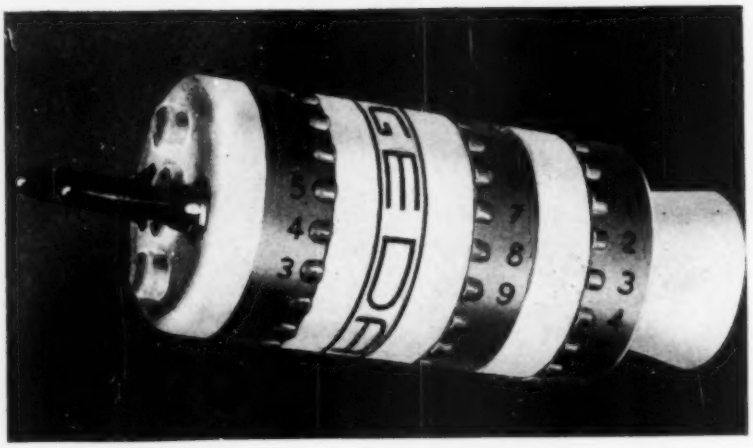
FUNCTIONAL COMPONENTS of dental equipment must be made with the greatest care known to the mechanical industries. Highest quality die castings are required and that is why Madison-Kipp products are often specified as in the case of the Non-rebreathing Valve and Vaporizer support here illustrated. Madison-Kipp is skilled and seasoned in die casting mechanics and invites your inquiries for co-operative effort.

MADISON-KIPP CORPORATION
206 WAUBESA STREET, MADISON 10, WISCONSIN

kipp

• Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools

Plug-In Decade Resistance Unit for Computers



Used with the L3 GEDA computer made by this company, this plug-in decade resistance unit is used for the setting of parameters in engineering and scientific problems, and may be applied to such experimental setups as audio and sub-audio circuit developments, and similar special-purpose analog computer developments. In addition, it may be used in classroom circuit instruction to permit the student to make circuit changes and observe their results.

Units are available in two types. One has a maximum resistance value of 10.6 ohms; the other a maximum resistance value of 10.7 ohms. Each unit has three dials showing the set resistance value to within 1 percent. The top dial controls a potentiometer, which permits the unit to be set to within 0.1 percent of any range value using a suitable resistance bridge.

Units supplied with each computer permit the constant coefficients to be easily set and stored on the removable problem board. In this way, the parameter values are retained when the problem board is taken from the machine for temporary storage.

A jack at the top of the unit is used to connect it to duplicate units or to other analog-computer circuits. The unit plugs into the problem board by two banana plugs at the left. These plugs are on standard $\frac{3}{4}$ inch centers.

The resistance unit is mounted in a plastic cylinder, with an overall length of 4 in. and a dia. of $1\frac{1}{4}$ inches.

Goodyear Aircraft Corp., Akron 16, Ohio

Analog Computer Records Random Counting Rates

Designed to record random counting rates on a linear chart with a constant computed statistical accuracy, a new recording counting rate computer makes use of Ohm's Law as the analog to the basic counting equation, $nT = N$.

A slidewire resistor is driven by a synchronous motor so that resistance (R) in the circuit is proportional to time (T). With fixed battery voltage (E) the current which is recorded is proportional to the counting rate (n).

The computer must be used with a scaling circuit adjusted for fixed count operation. The range of the instrument is controlled by the choice of scale factor (N = scale factor x 100) and the speed with which the slidewire is driven, which is adjusted by means of range gears.

Resistance of the circuit limits the maximum current to just enough to drive the recorder to full scale, limiting recorder deflection to full scale value for all counting rates above the maximum for any given range.

Motion of the slidewire is mechanically delayed a fixed amount to correspond with R_o, the specific value of which depends upon the resistance per turn, R_T, of the potentiometer shaft. The lower limit, which can be recorded, is determined by the maximum resistance of the slidewire.

North American Philips Co., Inc., 750 So. Fulton Ave., Mount Vernon, N. Y.

CONTINUED ON PAGE 220

"Flexible at low temperatures" reports Allied Control Co. on IRV-O-LITE XTE-30

Ability to *retain* its initial flexibility over long periods of operation at low temperatures is one of the major reasons why Allied Control Company, Inc., New York, has selected Irvington's IRV-O-LITE XTE-30 extruded plastic tubing. Tubing is used for insulating the flexible pigtail connections to the moving contact arms on Allied's Type BOY relays.

Because of its smooth interior surface, XTE-30 tubing slips easily over the finely stranded wire leads without breakage of strands. In addition to its high dielectric strength, the tubing affords mechanical protection from abrasion and tearing.

Other features of XTE-30 include high tensile strength and resistance to acids, alkalies and most solvents.

Look to
IRVINGTON
for Insulation Leadership
INSULATING VARNISHES
VARNISHED CAMBRIC
VARNISHED PAPER
VARNISHED FIBERGLAS
INSULATING TUBING
CLASS "H" INSULATION

Mail the coupon for technical specifications, dimensions and color range.

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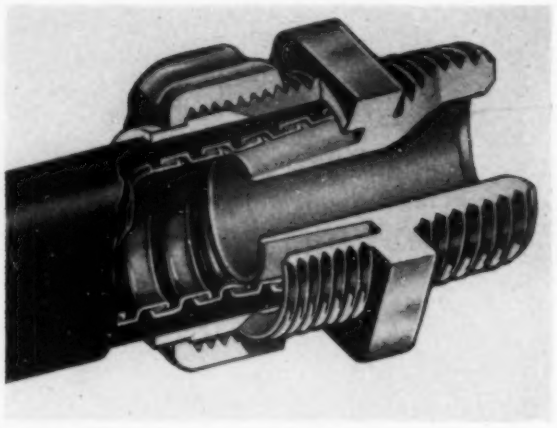
PE 9/53
Irvington Varnish & Insulator Co.
10 Argyle Terrace, Irvington 11, New Jersey
Gentlemen:
Please send me technical data sheet on IRV-O-LITE XTE-30 Plastic Tubing.
Name..... Title.....
Company.....
Street.....
City..... Zone..... State.....

Liquid Tight Fitting Joins With Any Conduit

Applicable for machine tool wiring or other similar electrical circuits exposed to corrosive liquids and mineral oils, this new fitting for liquid-tight flexible conduit mates with any conduit spiral, and does not have to be taken apart when installed. It is made in straight, 90 deg and 45 deg elbow designs, and accommodates conduit from $\frac{3}{8}$ to 2 in. trade size.

Another advantage of the fitting is that only one wrench size is needed for the gland and the body. A color coded plastic seal in the gland indicates a fitting's size, and that it is a liquid-tight type. When the colored seal is visible after installation of the fitting, the raceway is properly grounded. The end of the fitting facing the junction box has sufficient length to accommodate double locknuts used with sheet metal boxes. Also, the tapered pipe threads make a liquid tight connection with cast iron boxes. The body of the fitting is die cast from a high strength zinc alloy for the three smallest straight sizes. Other sizes are of malleable iron.

Since the metal spiral of liquid-tight, flexible conduit is enclosed in a tight-fitting plastic tube, the fitting ground connection can not be made outside. Instead, this is done inside the conduit, where the metal spiral's surface is exposed, and where the conical shaped ground wedges in a tight fit. The gland is tightened around the conduit and the joint is completed. Because the ground's wedge-type action doesn't depend on the particular conduit spiral, the fitting mates with any conduit spiral and does not have to be taken apart for installation.



The Thomas & Betts Co., Inc., 42 A Butler St., Elizabeth, N. J.

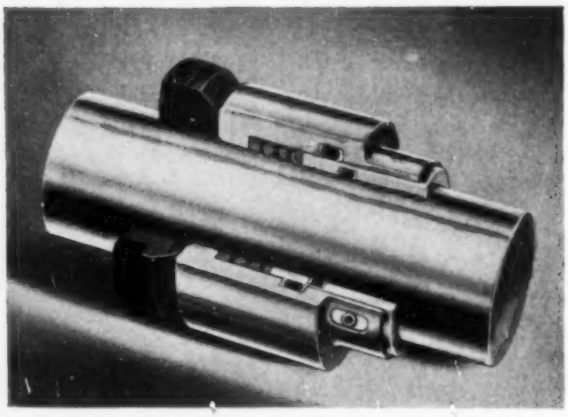
O-Ring Seals For Rotating Pump Shafts

Simplicity of design is the main feature of a line of new O-ring mechanical seals for rotating pump shafts. The small number of parts make for easy adaptability of this seal to withstand any liquid, on rotating pump shafts.

These O-ring seals are designed to give leakless operation of rotary shafts on centrifugal pumps handling chemicals, petroleum products, edible liquids, pulp liquors, and other liquids. They are furnished in type O, an unbalanced seal for pressures up to 200 psi; and in type OB (illustrated), a balanced seal for pressures up to and over 1,000 psi. Both types can be supplied with single or multiple spring, and in pin or sleeve-drive construction.

Type O seals are furnished for packing spaces $\frac{5}{16}$ in. and larger. In some cases, type O seals can be made for $\frac{1}{4}$ in. packing space. Type OB seals are furnished for packing spaces $\frac{3}{8}$ in. and larger.

The O-rings are available in Teflon, buna-N neoprene, or silicone. The metal parts coming in contact with the liquid can be furnished in any suitable metal.



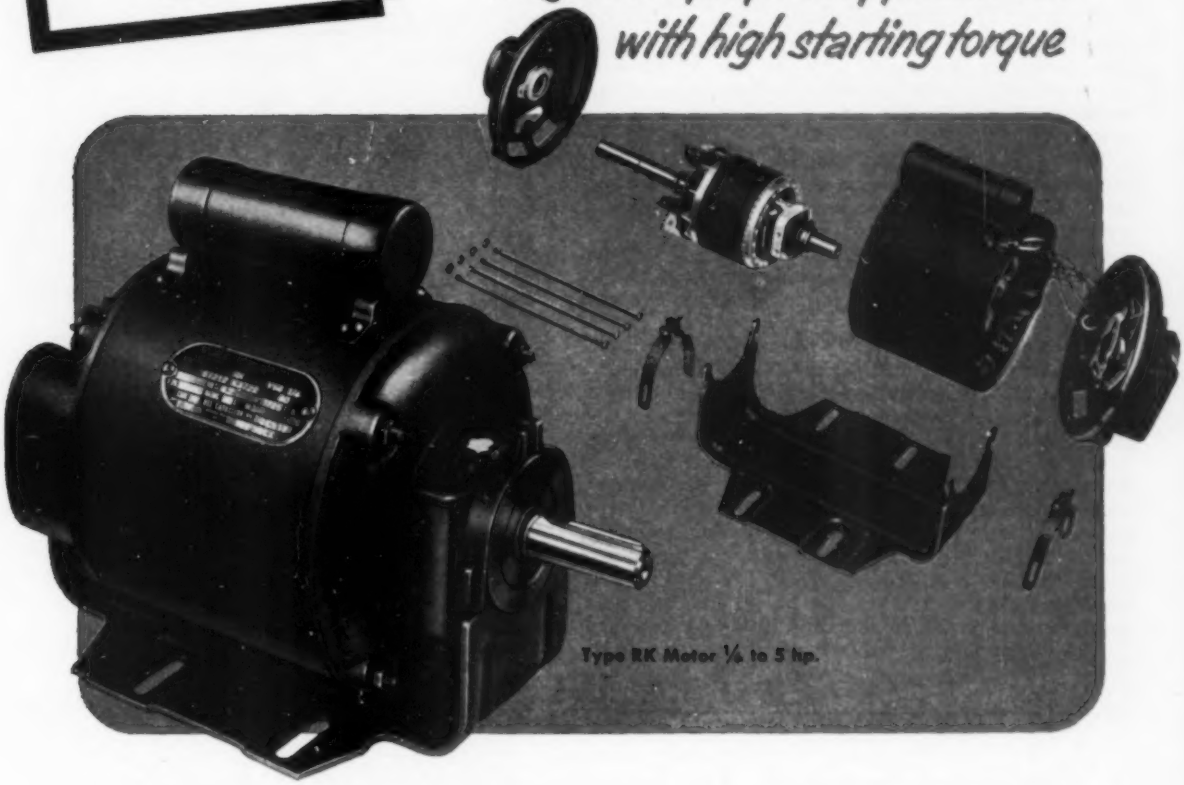
The Garlock Packing Co, Palmyra, N. Y.

A SMALL CAPACITY TENSILE TESTER, has been designed to measure the tensile properties of fibre, cloth, cord, rubber, and many other similar materials. It is operated by means of a handwheel which is graduated to read extension in increments of 0.001 inch. This handwheel drives a single thread worm gear which automatically holds the tension at any given point. Tension load is read by a single pointer which will remain at the point of maximum load until it is manually reset to zero. Standard capacities are available from 1 to 100 lbs with the following graduations: 1 lb x 0.01 lb; 5 lb x 0.02 lb; 10 lbs x 0.05 lb; 25 lbs x 0.1 lb; 50 lbs x 0.25 lb; and 100 lbs x 0.25 pound. The tester stands about 3 ft. high. John Chatillon & Sons, 85 Cliff St., New York 38, N. Y.

CONTINUED ON PAGE 222

Wagner
ELECTRIC MOTORS
...the choice of leaders in industry

Wagner
CAPACITOR-START MOTORS
for general purpose applications with high starting torque


Type RK Motor ¼ to 5 hp.

Wagner capacitor-start induction motors are a sound choice for applications where starting loads are fairly heavy, but which can be brought up to operating speed quickly. They have become increasingly popular for installation on equipment such as air conditioners, refrigerators, freezers, water pumps, motor-driven tools, and on similar fractional or integral horsepower applications.

These motors offer low maintenance cost—only a minimum of servicing is required—and they give many years of reliable service with unusual freedom from vibration and noise.

* * *

When you standardize on Wagner Motors—you get the advantages of a liberal warranty... of nation-wide service facilities, with on-the-spot service, replacement motors and parts available from 25 Wagner-owned Service Branches and more than 750 Authorized Service Stations. You can choose from a wide variety of types and sizes—single-phase or polyphase—(from 1/125 to 400 hp). Bulletin MU-185 gives complete information—write for your copy.

®Wagner Electric Corporation
EST. 1891

WAGNER ELECTRIC CORPORATION
6406 Plymouth Ave., St. Louis 14, Mo., U.S.A.

ELECTRIC MOTORS · TRANSFORMERS · INDUSTRIAL BRAKES
AUTOMOTIVE BRAKE SYSTEMS – AIR AND HYDRAULIC

BRANCHES IN 32 PRINCIPAL CITIES

M53-15

Direct Reading Impedance Bridge

Called the M1 GEDA impedance bridge, this impedance measuring instrument combining accuracy with operational simplicity can be used with precision by personnel unfamiliar with electronic circuits. It eliminates sensitivity controls, and gives direct reading of capacitance and resistance.

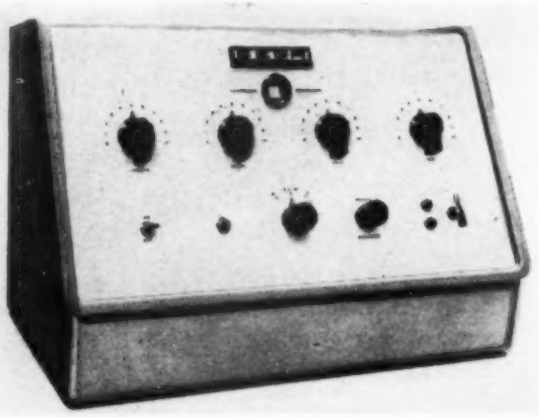
The M1 was designed especially for use with the linear and nonlinear analog computers made by this company, but can be used in all fields requiring precise measurements of resistance and capacitance.

Resistance is measured over two scales, 0 to 1 megohm and 0 to 10 megohms. The maximum error is 0.15 percent or 100 ohms, whichever is greater, with a probable error of less than 0.1 percent.

Maximum capacitance measurement is one microfarad. The maximum error is 0.25 percent or 0.0001 microfarad, whichever is greater, with probable error of less than 0.2 percent. Readings are repeated with an accuracy of .0.05 percent.

Basically, the instrument combines Wheatstone and Schering bridges. There are seven controls: an on-off switch; a capacitance-resistance selector; four decade resistors; and a phase balance. Two jacks provide for input, and a third jack for turret-type resistors of the plug-in decade-resistance type. The phase-balance control compensates for residual capacitance in the bridge, and corrects for the dissipation factor in the capacitor being measured.

A two-line tuning eye indicates the direction the decade resistors must be turned in order to achieve balance. No external generator signal is required for measuring the capacitance.



The M1 operates on 100 volts, 60 cycles, alternating current, weighs approximately 20 pounds, and is 20 inches long, 12 inches high, and 12 inches wide.

Goodyear Aircraft Corp., Akron 16, Ohio

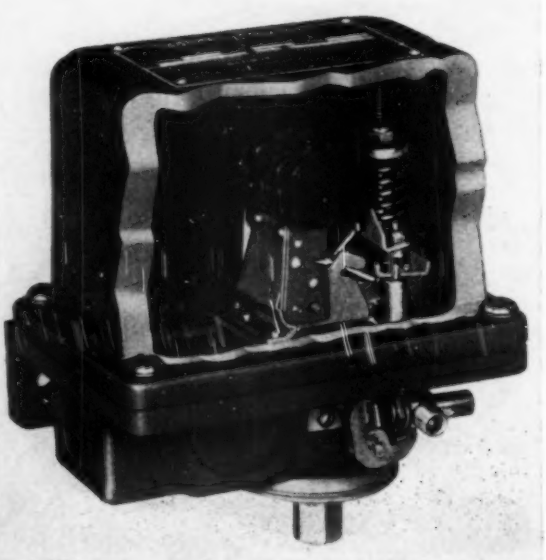
Pressure Switch In Explosion-Resisting Enclosure

A new pressure switch in an explosion-resisting enclosure for water pumps and air compressors is being used where explosive atmospheres are present or highly combustible fuels must be handled. Two types of this control are available to meet varying requirements. The water pump switch has a 20 to 80 psi pressure range, and the air compressor switch has a 40 to 200 psi pressure range. The air compressor switch is available with a two-way release valve. The control is adjustable over its entire pressure range.

The explosion-resisting enclosure consists of a two-piece casting with machined surfaces between cover and case. It has been designed to meet Class I, Group D specifications.

The stationary contact block and the movable contact yoke bar are made of non-carbon tracking Rostone. The structure is two pole, double break, silver-to-silver, visible, and vertical contact. The contact yoke is actuated by a $\frac{3}{4}$ in. wide non-adjustable beryllium-copper spring. Pressure acting against the diaphragm in opposition to the range spring forces the pressure plate upwards, changing the line of centers. The operating mechanism is of the positive snap-action type, giving positive contact regardless of range or differential spring adjustment.

Internal parts are treated to resist corrosion. The standard diaphragms are of impregnated fabric, with oil-resisting diaphragms available for applications requiring this.



Square D Co., 4041 North Richards Street, Milwaukee 12, Wis.

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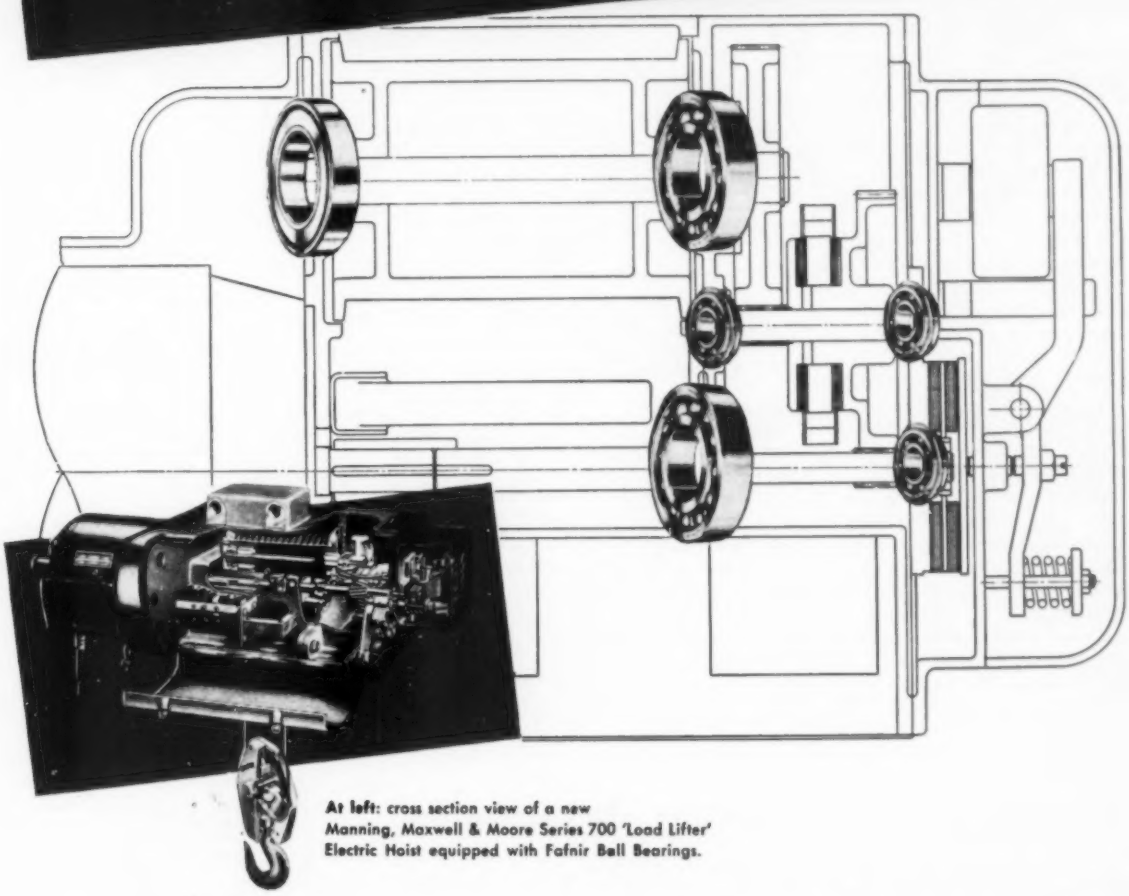
How an "Industrial Muscle" is kept from getting "Muscle-bound"



At left: cross section view of a new Manning, Maxwell & Moore Series 700 'Load Lifter' Electric Hoist equipped with Fafnir Ball Bearings.

Every bearing indicated in the diagram above highlights the strategy of Manning, Maxwell & Moore's electric hoist designers. Each eliminates a possible source of trouble caused by friction...on rope drum (bearing lubricated for life) on trolley assembly, on gear shafts, etc.

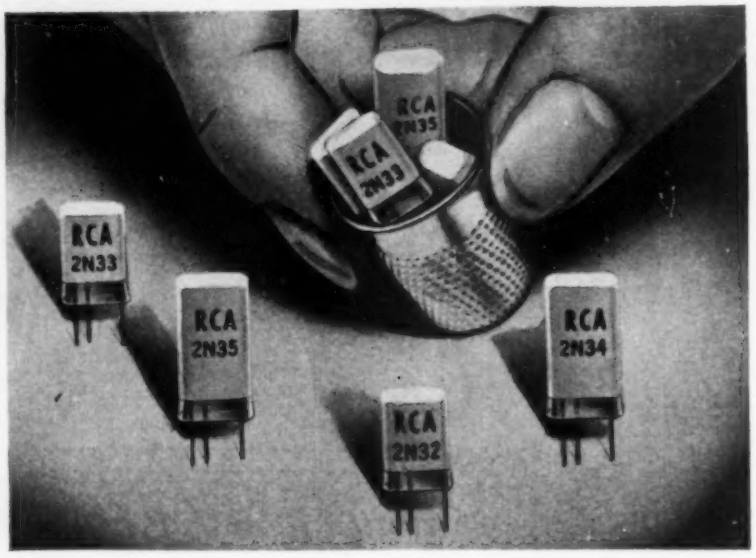
With critical turning points protected, this heavy-duty 1-ton capacity hoist is offered for three-shift lifting *every day in the year*. It lifts a ton, thirty feet a minute. Power is concentrated on lifting, not shared to overcome friction. It's smooth, steady, and efficient. Lubrication becomes a minor detail.

Fafnir is a supplier of Ball Bearings for Manning, Maxwell & Moore hoists and for hundreds of other industrial machines where Ball Bearing advantages improve performance and prolong service-life. The choice of Fafnir Ball Bearings, in case after case, has been influenced by the Fafnir "attitude and aptitude" . . . a way of looking at bearing problems from the designer's viewpoint, an aptitude for supplying the right ball bearing to fit the need. Maybe these attributes can help you solve a bearing problem. The Fafnir Bearing Company, New Britain, Connecticut.

FAFNIR **BALL BEARINGS**

MOST COMPLETE LINE IN AMERICA

Transistors For Use in Equipment Design



Four types of transistors, devices which will perform many of the functions of electron tubes, are now available for use by manufacturers and design engineers in the development of new equipment. The four types available are shown in the illustration and are:

1. The 2N32, a point-contact type intended for use in pulse or switching applications where an operating frequency for voltage-gain cutoff of 0.9 Mc, an operating frequency for current-gain cutoff of 2.7 Mc, and a high current amplification factor are important design considerations. The maximum overall length is 0.660 in., and width is 0.320 in. ±0.20 inch. Maximum ratings of the collector are: d-c voltage, —40 v max; d-c, —8 ma, max; dissipation, 50 mw, max. Maximum ratings of the emitter are: d-c voltage, —40 v max; d-c 3 ma max; ambient temp, 40 C maximum.

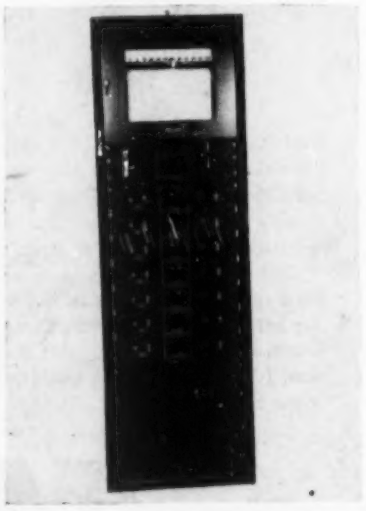
2. The 2N33, a point-contact type intended for use in oscillator applications in the 50 mc region. It is capable of providing a high current gain. Dimensions are the same as the 2N32. Maximum ratings of the collector are: d-c voltage, —8.5 v max; d-c, —7 ma max; dissipation, 30 mw maximum. Emitter rating: d-c, 0.8 ma, max; ambient temp, 40 C, maximum.

3 and 4. The 2N34 and the 2N35 are junction transistors of the P-N-P type and the N-P-N type respectively. Both types are intended for use in low-power, audio-frequency applications. They operate on very low voltages, have a current amplification factor approaching unity, and provide high operating power gain. Their maximum overall length is 0.885 in., and the width is 0.320 in. ±0.20 inch. Ratings for the 2N34 collector are: d-c voltage, —25 v max; d-c, —8 ma, max; dissipation, 50 mw max. Emitter rating is: d-c, 8 ma, max; ambient temp, 50 C maximum. Collector ratings for the 2N35 are: d-c voltage, 25 v max; d-c, 8 ma, max; dissipation, 50 mw, max. Emitter rating: d-c, —8 ma, max; ambient temp, 50 C maximum.

The manufacturers state that since there is little commercial equipment using transistors, these devices cannot be used in equipment designed for electron tubes without extensive changes first being made in the circuit design.

Radio Corp. of America, Tube Dept., Harrison, N. J.

Strain-Time Device Simplifies Data Recording



A recently developed strain-time recorder features accurate and automatic recording of strain in metals while eliminating the possibility of missing critical changes in the creep rate. Available in three models, models 108 and 109 are for use with the conventional contact-type (make-break, follow-up) strain indicators. Six or twelve input channels are furnished which can be operated independently or simultaneously, and the strain values are recorded on a single 11 in. chart, graduated in 100 units. The four ranges that are available for each channel—0.020, 0.050, 0.100 and 0.250 inch—are designed to be individually controlled.

For short-time tests, the recording time can be reduced to 12 seconds or 4½ sec. per print. At 4½ sec. per print, complete cycles are made in 30 sec. for a 6-channel recorder and in 60 sec. for a 12-channel recorder. Also available is a selector panel to allow operation of all 6 or 12 printing records from any one of the single inputs.

In model 110, the strain-sensing means is provided by electrical differential transducers for direct attachment to extensometer rods. This model, designed for high-temperature tensile testing, records strain values of seven simultaneous tests on a single 11 in. chart, graduated in 100 units.

Gilmore Industries, 5511 Euclid Ave., Cleveland 3, Ohio

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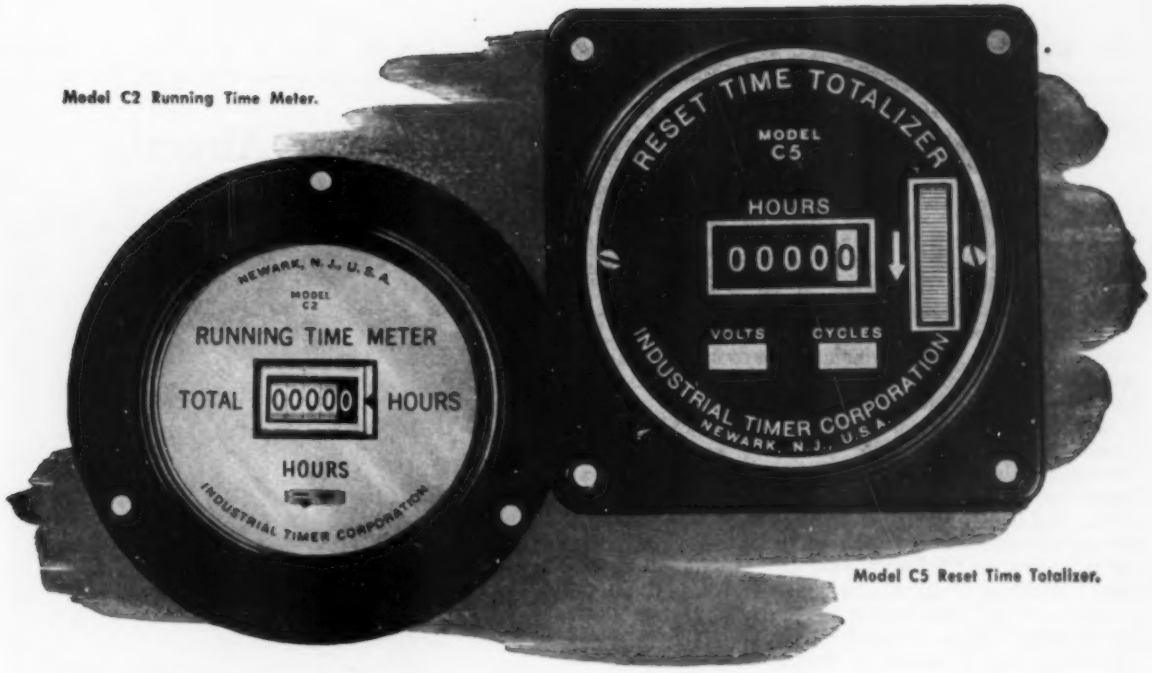

Model C2 Running Time Meter.

Model C5 Reset Time Totalizer.

NOW BOTH! Reset and Non-Reset Elapsed Time Meters

For applications where it may be desirable to reset to zero at any time, Industrial Timer now offers Reset Time Totalizers, in addition to its Running Time Meters.

SYNCHRONOUS MOTOR DRIVEN. Both types of elapsed time meters provide you with an exact record of machine hours on A.C. operated machines... up to 100,000 hours with "electric clock" running accuracy. Both utilize heavy duty synchronous motors that are self lubricating for long life. And both are available in enclosed and open type models. Running Time Meters are enclosed in black bakelite cases. Reset Time Totalizers in steel housings with baked black finish.

WIDE VARIETY OF APPLICATIONS. These Industrial Elapsed Time Meters permit you to compute readily production costs on A.C. operated machines — predict replacements for equipment of predetermined life expectancy. They can be used in a wide variety of applications such as: radio transmitters, vacuum tube devices, refrigerators, oil burners, molding machines, life test equipment, diesel generators, conveyors and many other types of machinery and equipment. For technical data, request Bulletin 88-53.

Reset Time Totalizer — Model Designations

CASED	OPEN	COUNT	RANGE	VOLTAGES	CYCLES
C 5		1/10 hr.	10,000 hrs.	115,220	60,50,25
	C 7	1/10 hr.	10,000 hrs.	115	60,50,25
C 5A		1 hr.	100,000 hrs.	115,220	60,50,25
	C 7A	1 hr.	100,000 hrs.	115	60,50,25

Running Time Meters — Model Designations

CASED	OPEN	COUNT	RANGE	VOLTAGES	CYCLES
C 2		1/10 hr.	10,000 hrs.	115,220,440	60,50,25
	C 4	1/10 hr.	10,000 hrs.	115	60,50,25
C 2A		1 hr.	100,000 hrs.	115,220,440	60,50,25
	C 4A	1 hr.	100,000 hrs.	115	60,50,25
C 2D		1/10 min.	10,000 min.	115,220,440	60,50,25
	C 4D	1/10 min.	10,000 min.	115	60,50,25
C 2F		1 min.	100,000 min.	115,220,440	60,50,25
	C 4F	1 min.	100,000 min.	115	60,50,25

MANUFACTURERS OF THESE AND OTHER TIMERS AND CONTROLS FOR INDUSTRY — CAM TIMERS • TIME DELAY TIMERS • AUTOMATIC RECYCLING TIMERS MANUAL SET TIMERS • INSTANTANEOUS RESET TIMERS.

Timers that Control the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

115 EDISON PLACE, NEWARK 5, N. J.

Piston Type Hydraulic Motors For Aircraft

Piston type hydraulic motors for aircraft are available in thirty-two standard sizes capable of handling up to 57.8 horsepower and an output of 3000 psi. A variety of porting arrangements and mounting flanges can be provided.

Overall efficiency of the motors is said to be better than 92 percent at rated speed and pressure. Operation can be continuous, intermittent, continuously reversing, or stalled without damage to the motors when protection is provided by a proper system relief valve.

The time required to accelerate the hydraulic motors from stand-still to maximum intermittent speed with no external load using the torque available at 4500 psi (limited usage) varies between 0.0019 seconds for the smallest size motor, and 0.0051 for the largest motor. With zero load, the minimum number of revolutions to stop from maximum intermittent speed is between 0.116 and 0.167 for all motor sizes. Mounting of the motors is unrestricted.

The model MF3906-30, one of the smaller aircraft 3000 psi hydraulic motors, is small enough to fit in the palm of a hand, but is capable of transmitting approximately 4.3 hp at recommended speed and pressure. It transmits approximately 9.8 hp at maximum intermittent speed and pressure. Weight of this unit is 2.6 pounds.

Vickers, Inc. 1400 Oakman Blvd., Detroit 32, Mich.

Sensitive, Electro-Dynamic Balancing Machines

In less than a minute, and in a single run, a new type of an electro-dynamic balancing machine will accurately determine the amount and locating of dynamic and static unbalance in rotating parts. Available in nine different models, they have weight capacities which range from a few ounces in the smaller machines, to over 100 tons.

Each balancer has an electrical measuring system, without electronic tubes or oscillograph, that will indicate unbalances caused by displacements of as little as 0.00004 in. from the center of gravity. Such measurements are indicated on a wattmeter which records only unbalance vibrations, and is unaffected by disturbance vibrations.

The weight in pounds, which each machine can handle, is: R13, 0.1 to 22; R23, 0.3 to 66; R33, 1.0 to 220; R43, 3 to 660; R53, 11 to 2,200; R63, 33 to 6,600; R73, 110 to 22,000; R83, 330 to 66,000; R93, 1,100 to 220,000.

Cosa Corp, 405 Lexington Ave., New York, N. Y.

SELF-LOCKING CABLE grips for use with wire, hemp or cotton ropes, grip the rope equally on both sides, and automatically grip the rope tighter as stress is applied. No nuts or bolts involved, and as the rope is not bent, fastening and removal is simplified. Each clamp is designed to fit different sizes of wire rope or strand ranging up to 2 in. in diameter. The Wesloc Screw & Tool Co., 17 West 32nd St., New York, N. Y.

A FLUID CONTROL VALVE operated by a mechanical clock, is a normally closed valve which must be opened manually, and which is closed automatically with snap action at the end of its time setting. It is suitable for use on water, brines, liquefied petroleum gasses, air, steam and other fluids, and can be operated at 250 F in any position. The Erie Mfg. Co., 300 N. 8th St., Milwaukee, Wis.

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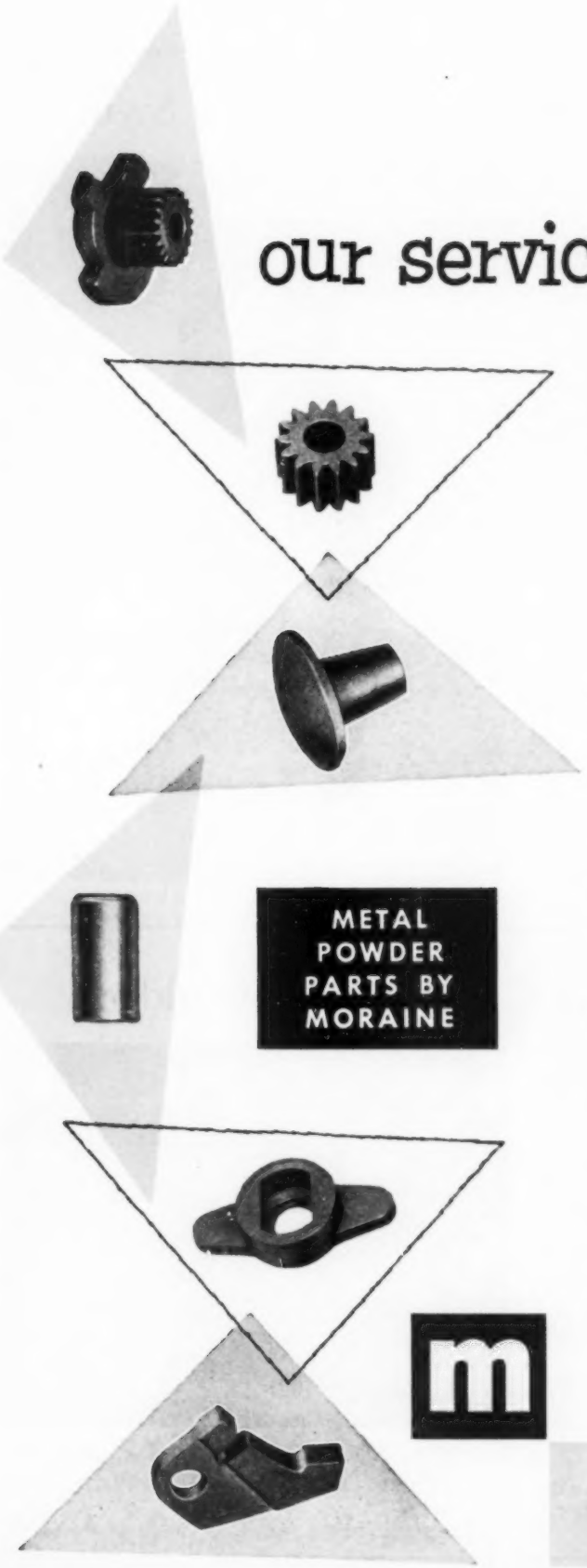


our service to industry grows with experience

Thirty-two years and several billion parts ago we began learning about powder metallurgy. Our knowledge of this business is now considerable, yet even today there's no end in sight to what can still be learned.

Applying our always-growing knowledge enables us to find new ways to improve the physical properties of our metal powder products; to offer an ever-broadening range of materials to our customers; to make possible more and more applications.

Our position in the field of powder metallurgy is a proud one . . . but we take a greater pride in the fact that our products are providing industry with a means of improving performance while cutting costs.

moraine products

DIVISION OF GENERAL MOTORS CORPORATION, DAYTON, OHIO

Widely Adjustable Explosion Proof Limit Switch

An explosion-proof, heavy duty precision limit switch, designed for use on all types of machinery and industrial equipment is listed as suitable for hazardous locations of Class I, Group C and D, and is made so that the user may adjust the operating head to any of four horizontal positions. The new switch, designated IMLI-EI, has a roller arm assembly that may be reversed to position the actuator roller on either side of the actuator arm. The roller arm is field adjusted to operate clockwise, counterclockwise, or in both directions. The actuator arm assembly is adjustable through 360 degrees to any of 870 positive lock positions at intervals of 0.4 degrees.

The manufacturer claims that this is the smallest explosion-proof snap action switch available. Including the adjustable head, the switch case measures 6 in. high, $2\frac{1}{8}$ in. wide, and $1\frac{3}{4}$ in. in depth.

The die cast aluminum enclosure has a $\frac{1}{8}$ in. thick porous bronze plate fitted over the enclosure opening to vent the basic switch cavity. This porous plate prevents any great pressure build-up in the switch cavity due to the ignition of any explosive atmosphere present. The path through the plate also serves to extinguish the flame, and cool the hot gases below the ignition point of the surrounding explosive atmosphere.

The new switch has been listed for 20 amp., 110, 220, or 440 volts a-c; $\frac{1}{2}$ amp. 115 volts d-c; $\frac{1}{4}$ amp., 230 volts d-c; $\frac{3}{4}$ hp 110 volts a-c; $1\frac{1}{2}$ hp, 220 volts a-c. Pilot duty rating is 125 volts a-c; 6 amp. normal, 60 amp. inrush; 250 volts a-c; 3 amp. normal, 30 amp. inrush; 480 volts a-c, 1.5 amperes normal, 15 amperes inrush; 600 volts a-c, 1.2 amperes normal, 12 amperes inrush.

Micro Switch, Freeport, Ill.

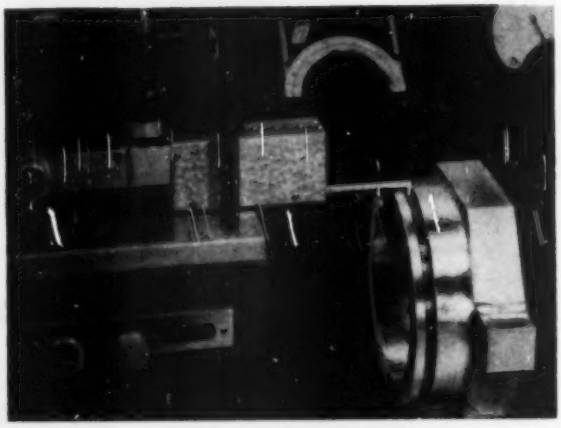
Surface Roughness of Grooves and Shoulders

Measuring the surface roughness across the bottom of flat-bottomed grooves to a $\frac{1}{4}$ in. depth and behind shoulders to a $\frac{1}{4}$ in. height is possible with the new type KB Profilometer tracer unit shown. When measuring crosswise, it permits $\frac{1}{16}$ in. length of trace in grooves of $\frac{5}{32}$ in. width, and greater length of trace in wider grooves. This tracer can also be used in ID's from $\frac{3}{4}$ in. to flat, and on all OD's and flats where the part can be mounted on a linear Piloter with the work surface horizontal. The maximum horizontal reach: distance, from tracer point to end of piloter slide, $2\frac{9}{16}$ inches.

The tracer point has a range of vertical travel of 0.030 in., permitting roughness measurement across curved surfaces where the chordal height does not exceed 0.025 inch.

This tracer has no skids, and the tracer point is at the bottom of a vertical extension from the end of a long beam. Because of this construction, this tracer must be supported and moved mechanically by a linear Piloter. When measuring surfaces smoother than 2 microinches, care should be taken to avoid extraneous vibration.

At the 0.1 in. per-second tracing speed provided by the linear Piloter, (which must be used with the tracer) surface irregularities with peak-to-peak spacing greater than 0.010 in. are not measured.



Micrometrical Mfg. Co., 345 S. Main St., Ann Arbor, Mich.

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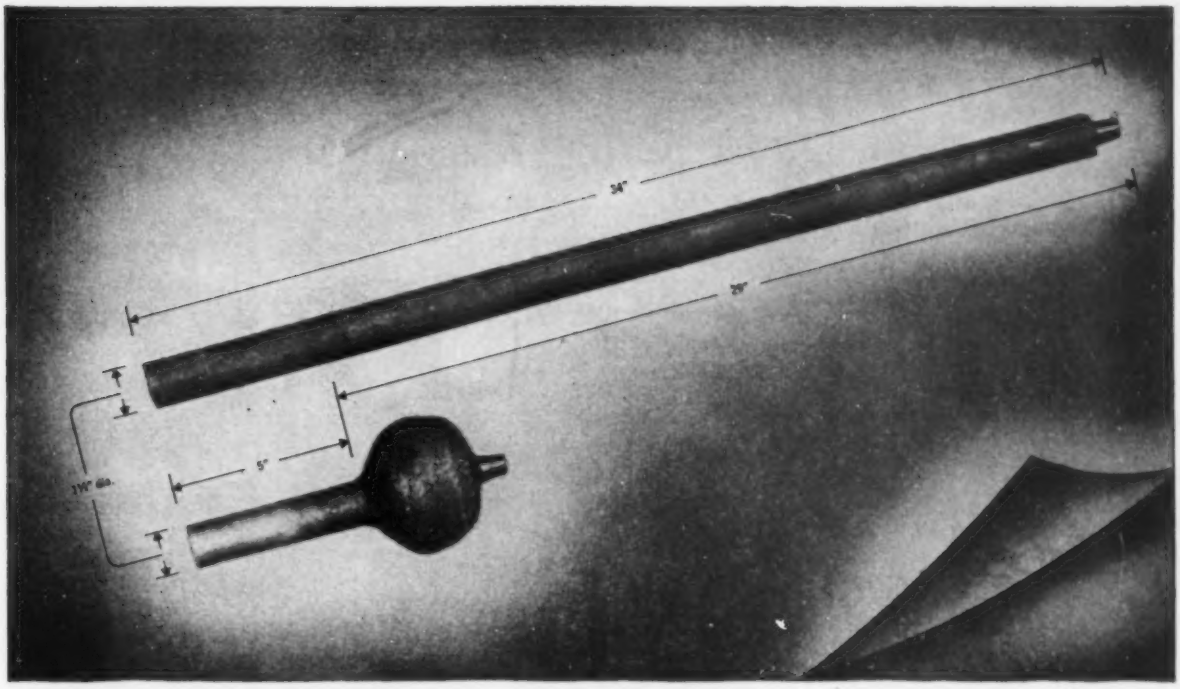


UPSETTING some old ideas as to the size of UPSETS!

Any good forging handbook will tell you that unsupported steel can be upset only three diameters. But today's new forging techniques at UTICA have revised that. As example, 29" of this Inconel X 1½" bar were upset into the bulb on the end. This bulb, after precise forging and finishing, will become a very high speed turbine wheel with integral shaft.

UTICA electrical upsetting gives special advantages

Today both old and tough *"new"* metals are being upset—on a production basis—in UTICA's battery of upsetting machines. Many special forging advantages result—and unique product design gains too. Primarily the upsetting brings greater strength and ruggedness through controlled grain flow. It also makes new designs possible—designs previously impractical. Most important of all, it drastically reduces not only material costs but machining time and costs as well.

A product of the UTICA "Quality First" program

This is just one development in the long range UTICA program—which combines new methods and new machines to mass produce quality forgings...accurate to a very few thousandths... many produced from the *"new"* hard-to-handle metals. Today UTICA production covers jet blades and other defense items—perhaps tomorrow we can serve you with some of the great forging advances developed during the past few years.

Jobs available for technically trained personnel.

Our new folder "File Facts on Precision Forgings" outlines UTICA'S methods and facilities. Send for your free copy today. No obligation.

PRECISION···· U TI CA ····FORGINGS
TRADE MARK

UTICA DROP FORGE & TOOL CORPORATION
UTICA 4, NEW YORK

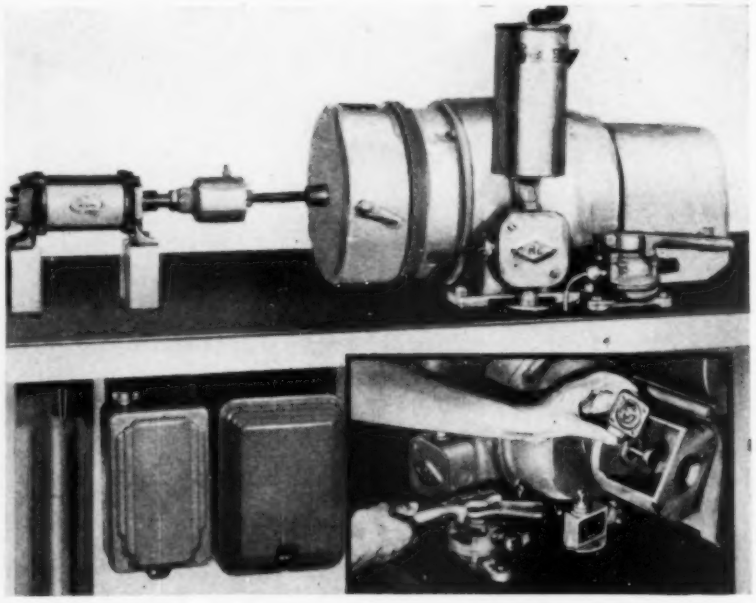
MAKERS OF THE FAMOUS UTICA LINE OF DROP FORGED PLIERS AND ADJUSTABLE WRENCHES

Fast, Direct Acting, Magnetic Brake

Use of a new "doughnut" type magnet in a magnetic brake makes it possible to extend the motor shaft entirely through the brake, if necessary. On motorized reducers this feature permits the utilization of both the high and low speed shafts. Also, a new set-and-release action eliminates all conventional levers and linkages. The hand release is accomplished by an arm-and-cam action. Spring pressure holds in the release position. It can be manually reset, or it automatically resets when the current is applied. In addition, the shaft of the motor used with this unit is hollow.

Spring pressure compensates for lining wear, and safety stops limit the magnet-to-armature air gap when the maximum wear position is reached. This prevents any possibility of magnet overloading.

Typical of the set-ups using this unit is the one illustrated above. It involves the lapping of three ports in a valve to a precise dimension. The operator first positions the valve in the fixture, locking it in place by activating the ram. The fixture, which is connected to the motor's shaft, rotates with the valve when the motor is started. As the valve rotates, the operator laps the three ports simultaneously through the opening in the end of the fixture. Additional uses include grinding, honing, spinning and turning. The brakes are available in 3, 6, 10, and 25 ft.-lb. continuous duty ratings, and in 3, 6, 10, 15, 25, and 35 ft.-lb intermittant duty types.



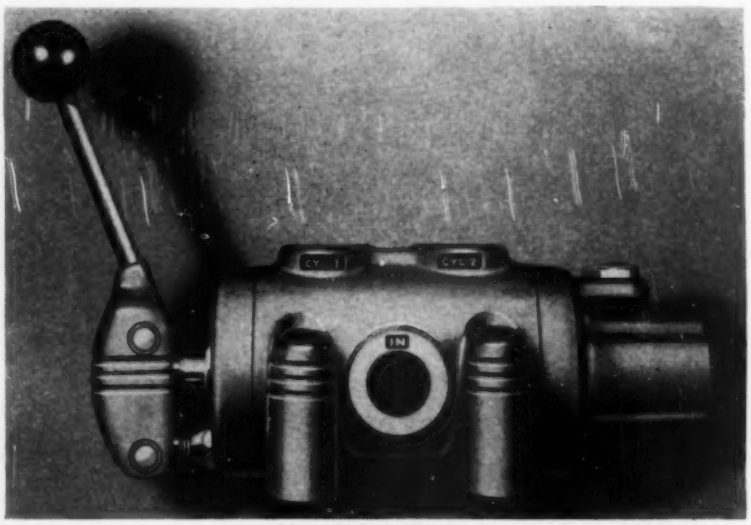
Reuland Electric Co., Alhambra, Calif.

Ball Detent Four-Way Hydraulic Valves

Ball detents to hold the valve piston in any given position is a feature of a new hydraulic 4-way valve that can be mounted vertically as well as horizontally, and prevents vibration from causing movement of the valve piston.

The valve is available with one, two, or three ball detents. With one detent the valve piston is held in center position; with two detents the valve piston is held in either end position; and with three detents the valve piston is held in both end and center positions.

Designed for 1500 psi pressure, the valves are available in three types of operation: threaded stem, lever, and knob; in seven sizes: $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, and $1\frac{1}{2}$; and in five piston designs to meet the requirements of any circuit. The valves can also be furnished with left hand assembly.



Rivett Lathe & Grinder, Inc., Brighton 35, Boston, Mass.

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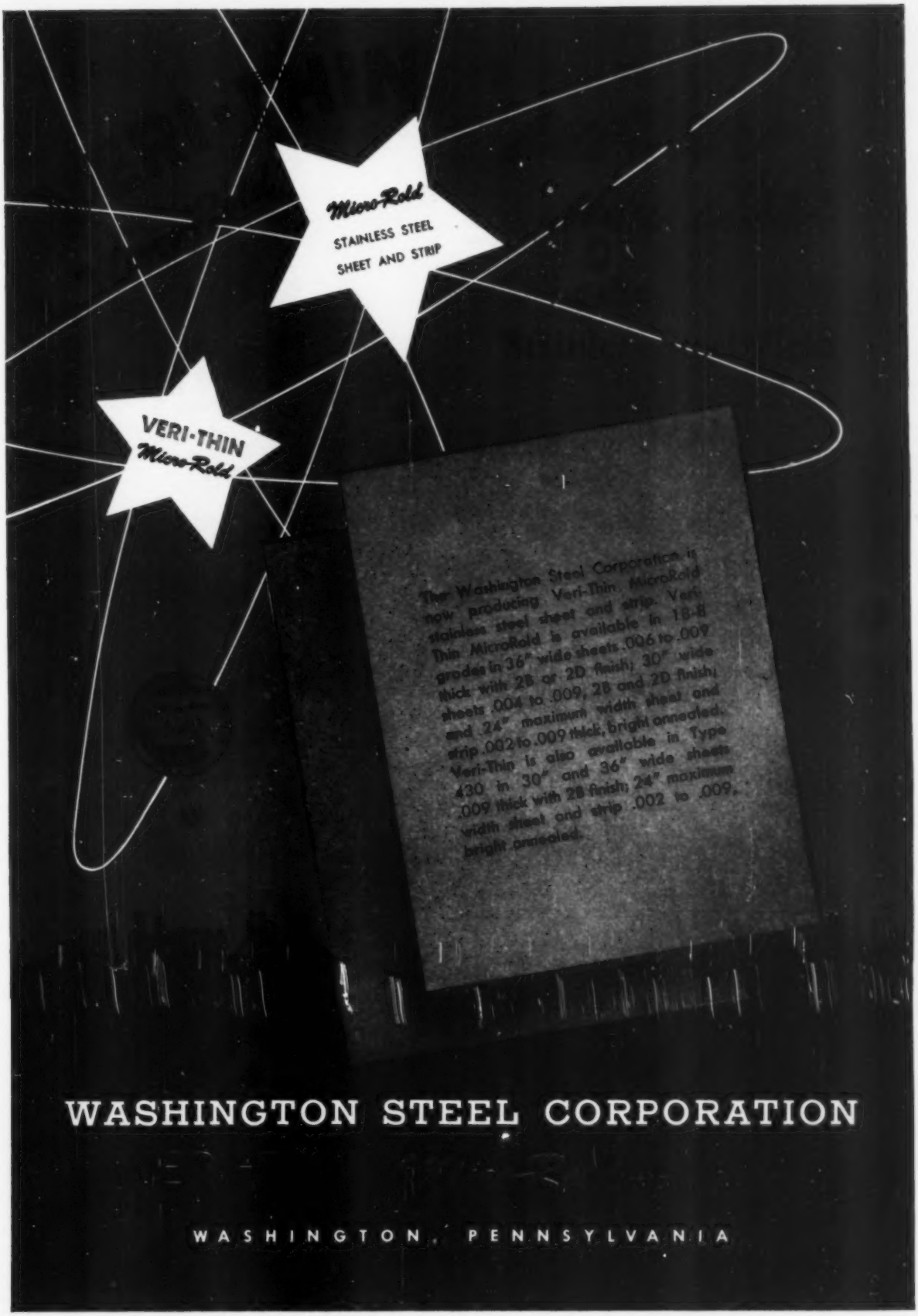
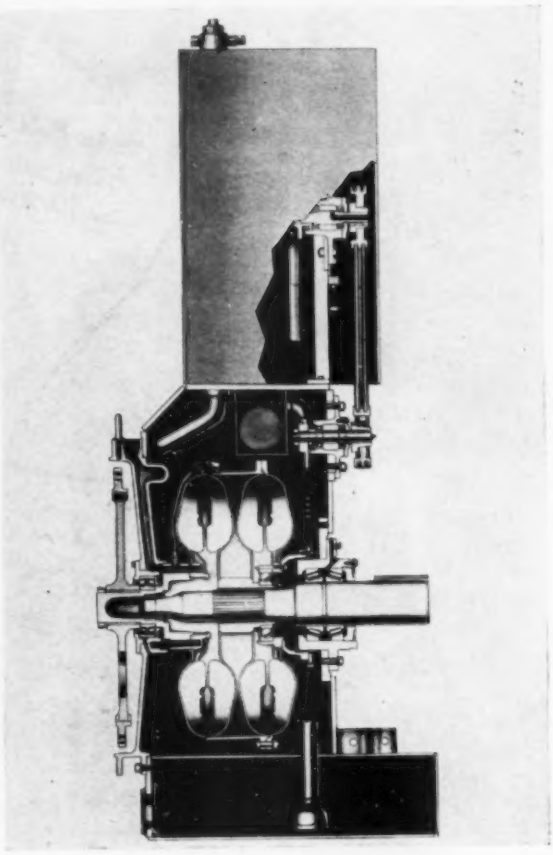

Micro-Rold
STAINLESS STEEL
SHEET AND STRIP
VERI-THIN
Micro-Rold
The Washington Steel Corporation is now producing Veri-Thin MicroRold stainless steel sheet and strip. Veri-Thin MicroRold is available in 18-8 grades in 36" wide sheets .006 to .009 thick with 2B or 2D finish; 30" wide sheets .004 to .009, 2B and 2D finish; and 24" maximum width sheet and strip .002 to .009 thick, bright annealed. Veri-Thin is also available in Type 430 in 30" and 36" wide sheets .009 thick with 2B finish; 24" maximum width sheet and strip .002 to .009, bright annealed.
WASHINGTON STEEL CORPORATION
WASHINGTON, PENNSYLVANIA

Hydraulic Power Take-Off For Heavy Duty Engines



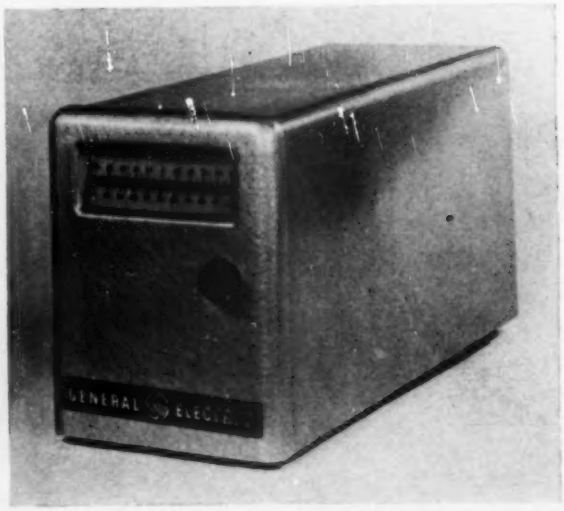
More effective hydraulic linkage to heavy duty industrial applications is said to be possible with the development of a new disconnecting hydraulic power take-off that will give a quick, positive disconnect of the power source from the driven equipment. The model HUD power take-off transmits the peak torque from any type engine, while providing a fluid protection against starting loads, shock loads, and overloads, with impact loads said to be reduced 70 percent or more.

Controlled by the operator, disconnection of the hydraulic power take-off is actuated from a master control valve, which operates differential pressure valves to dump the oil within the model HUD into a reservoir in a matter of seconds. New type rubber diaphragm valves operating in a radial direction accurately allow for fluid dumping and re-filling. Release is positive, without the use of engine cut-off clutches. The dampening effect of the unit prevents load oscillation, and will keep the power steady in one direction.

With this new unit, the load can be picked up simply by opening the throttle, the drum clutch can be engaged with the engines idling, and multiple engines can be synchronized while operating at slightly different speeds. Designed for limited space application, the power take-off is available in coupling sizes 21 and 27 inches, to handle up to 600 hp engines. It has an independent cooling radiator, with a fan-drive and cooling fan assembly.

Twin Disc Clutch Co, Hydraulic Div., Rockford, Ill.

High Sensitivity Portable Galvanometer



Giving a field of more than twice the strength obtainable with the chrome-steel magnets previously used, the new alnico magnets used in a redesigned line of portable galvanometers have resulted in a high sensitive instrument for measuring low values of current voltage.

The galvanometers are designed so that the entire coil and suspension element can be removed from the magnetic assembly and replaced by a system of different sensitivity, without remagnetizing or disturbing external connections.

Applications for the portable units include temporary or permanent installation for testing of instruments, materials, and many types of apparatus. The units also may be used with bridges and other devices which require an external galvanometer.

The galvanometer element and optical system are mounted in a case 6½ x 8 x 16 in., with the scale, which is marked 50-0-50 and 0-100 in 1 mm divisions, tilted at a 15 deg angle. An adjusting knob for setting the element on zero is located on the front to permit rolling back of the hairline to give an effective scale of 280 mm.

General Electric Co., Schenectady 5, N. Y.

CONTINUED ON PAGE 234

A Customer Reports:

"Production Costs Reduced...Product Improved with Asarco Continuous-Cast Bronze"

The Denison Engineering Company, Columbus, Ohio, uses ASARCO Continuous-Cast Bronze rod in preference to ordinary sand-cast bronze for several important parts (cylinder barrels, shoes of piston-and-shoe assemblies, etc.) of its heavy-duty hydraulic pumps and fluid motors. The alloy is 84% copper, 10% tin, 2.5% lead, and 3.5% nickel.

This company finds the following advantages in Asarcon Bronze:

1. Reduced machining time; can be machined on automatics.
2. Less scrap; the rod is delivered in exactly the diameter and length desired.
3. Stronger finished product; because of exclusion of impurities and even dispersion of alloy constituents, physical characteristics are substantially better than those of the same alloy cast by other methods.

All Asarcon stock for machining is Medart-straightened and furnished within a general tolerance of +0.004" to −0.006" on O.D. Tube concentricities are within 1.5% of wall thickness.

As proved by Denison, Continuous-Cast Bronze can save you money. A variety of alloys and special shapes in lengths up to 20′ can be cast to order. Use coupon below for free catalog containing complete descriptive material.

ASARCO® CONTINUOUS-CAST RODS · TUBES · SHAPES

American Smelting and Refining Company

OFFICES: Perth Amboy Plant, Barber, New Jersey • Whiting, Indiana

West Coast Sales Agent:
KINGWELL BROS. LTD., 457 Minna Street, San Francisco, California

American Smelting and Refining Company
Perth Amboy Plant, Barber, New Jersey

☐ Please send me a free copy of the 12-page catalog "Asarco Continuous-Cast Bronze."
☐ Please send a salesman

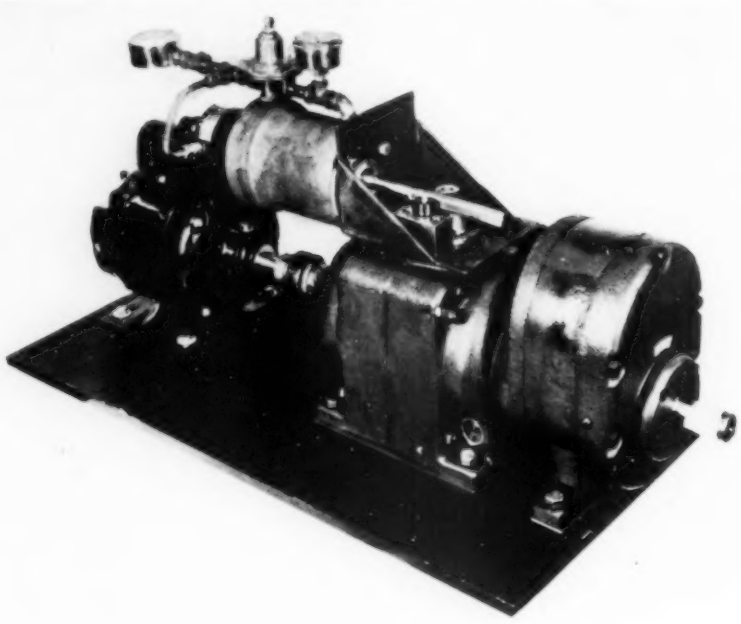
Name _____ Title _____

Company _____

Address _____

City _____ Zone _____ State _____

Sensing Device Controls Variable Speed Drive



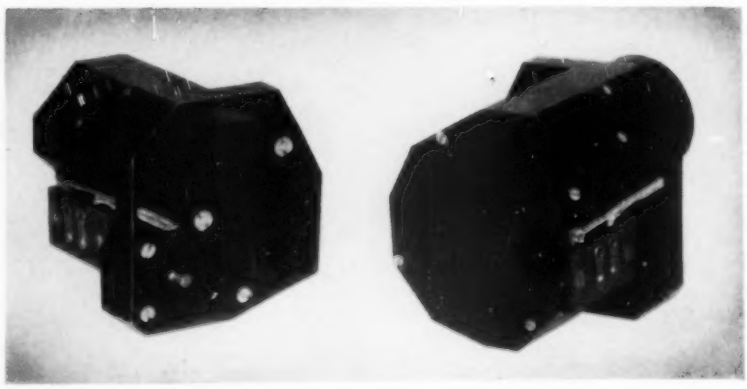
This variable speed transmission unit fitted with the Conoflow operator is able to give rapid, accurate and linear response to signals from a sensing device in the system. This sensing element may be controlled by flow rate, pressure, ph, temperature, humidity, liquid level or other variables, and will cause the transmission to deliver the right speed predetermined for any particular condition. Since the positioner actuating arm movement is directly proportional to the control pressure, and since the output speed of the transmission varies directly with the movement of its control level, the output speed of the transmission from zero to nearly maximum varies linearly with the control pressure, and therefore directly with the signal from the sensing element.

This linearity of response, plus the range of speeds available from the transmission, (all speeds from top to zero and reverse) make the unit applicable to continuous processes where operating conditions vary continuously, but where rapid control is necessary. Zero speed is at a control pressure of 3 psi, and any maximum speed is delivered at 15 psi with $\frac{1}{2}$ speed at $7\frac{1}{2}$ psi, $\frac{1}{4}$ speed at $3\frac{3}{4}$ psi, and so on.

The transmission is available with or without a built-in motor of all types, including explosionproof, and can be had with built-in gearboxes, both worm and helical, to give any desired top speed. The entire unit is mounted with 6 bolts.

Graham Transmission, Inc., Menomonee Falls, Wis.

Compact Power Package Capable of High Accuracy



This compact power package, capable of high accuracy, and of delivering a high output torque, is intended for timing and programming purposes to be used in aircraft and missile applications. However, its use can be extended to other applications.

The unit, known as type PMGG-X10, is made up of a PM motor of special design, a high accuracy governor, a high torque gear train, and is designed for nominal $27\frac{1}{2}$ volt d-c operation. The overall package can fit into a space of approximately $2\frac{1}{4}$ in. cube. Its speed accuracy is within $\pm\frac{1}{3}$ of 1 percent over a range of ± 10 percent voltage variation; and is within $\pm\frac{2}{3}$ of 1 percent over a range of ± 20 percent in voltage variation. The current consumption is approximately $\frac{1}{4}$ ampere.

In its present form, the output shaft operates at $1\frac{1}{3}$ rpm and is capable of handling loads up to 100 in.-ounces.

It is available for other speed and torque ranges, and with slip clutches and electro-magnetic clutch and brake combinations.

Pacific Instrument & Controls Co. 2317 Westwood Blvd., Los Angeles 64, Calif.

CONTINUED ON PAGE 236

Sensational

FOR PERFORMANCE...

WICHITA STANDARD Air-Tube DISC CLUTCH
SPECIAL VENTILATED Air-Tube DISC CLUTCHES
WICHITA LOW INERTIA Air-Tube DISC CLUTCH

WICHITA *Air-Tube* CLUTCHES

These three simple, compact, powerful, trouble-free Air-Tube friction clutches combine all the advantages inherent in air operation, such as: convenient remote control, small manual pressure required for full torque, smooth starting and quick disengagement.

They are engineered to give longer service at a lower operating cost because each requires very little maintenance. Many test runs of Wichita Clutches have exceeded 2½ million engagements and still no failures occurred. Such performance is proof of the sound engineering behind Wichita Clutches. Pick the Clutch *you* need for the job! *Call the nearest Wichita Engineer for complete detailed information.*

OTHER OUTSTANDING ADVANTAGES

- Safer Operation
- Cooler Running
- Minimum Slippage
- No Backlash
- Built in Standard and Low Inertia Types, All Positively Ventilated
- No Lubrication
- No Adjustments

CALL THE WICHITA ENGINEER NEAREST YOU

WICHITA DISTRIBUTORS

Brahm-Lahner, Inc., Detroit, Michigan
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Smith-Keser & Co., New York, N. Y.
Frank W. Yarline Co., Chicago, Ill.
Power Rig & Equipment Co., Inc., Long Beach, Calif.
Robert R. King Co., Cleveland, Ohio

WICHITA
WICHITA FALLS, TEXAS, U.S.A.

Ad 6DN

Vacuum Sealed, Pressure Operated Potentiometer

A new unit in potentiometer pressure gages is the Baroresistor, a unit having the potentiometer winding and mechanism hermetically sealed in a vacuum, and which operates linearly as a function of absolute pressure over a range of 0-15 psi. By sealing the operating parts in a vacuum, a zero reference pressure unaffected by temperature is possible. Another feature is that the unit can be used on liquid or gas systems, as the pressure medium does not contact the windings.

In operation, pressure is admitted to the inside of the bellows through the header connection at the top. Pressure enters the bellows and causes the bellows to exert a force against a precision reference spring. This spring is stiff compared to the bellows so that the resulting motion is not influenced to any extent by the bellows spring characteristics. This results in a low hysteresis and a motion linearly proportional to pressure. Also, the small expansions of the support rods with temperature do not affect the accuracy, because the bellows is a force output device rather than a displacement device.

The motion of the bellows is mechanically doubled by an all flexible linkage. Therefore, the mechanism is free of backlash, coulomb friction, and indefinite bearing position. A noble metal wiper at the end of the linkage moves across the precision winding.

The winding is conduction cooled to permit as much as 75 volts across the resistance element continuously. The wiper and winding materials are said to give a winding life of 1,000,000 full scale cycles.

This pickup may be used in any electrical circuit where a pressure actuated potentiometer is needed. The high output voltage can be used without amplification. Some applications are: as a pressure transducer for telemetering or recording purposes; as a servo loop gain adjustment; and as an element in computing functions such as a mach number, and others.

Trans-Sonics, Inc., Bedford Airport, Bedford, Mass.

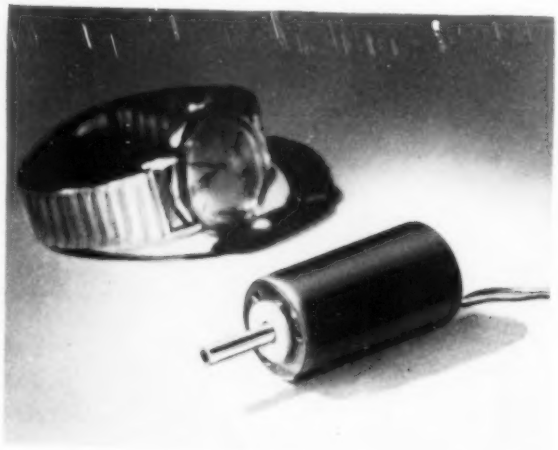
Small Motors For Confined Areas

A line of small precision motors, especially designed for operation in confined areas where minimum size and weight are essential, are only one inch in diameter, and may be used to operate such miniaturized components as: fans, blowers, instruments, controls and other low-power drive units.

Designed for long life and high efficiency, these motors have a maximum 115 volt input and can be used for single, two, or three phase 400 cycle operation, at running speeds of approximately 10,500 and 21,000 rpm, and for single or two phase 400 cycle operation at a speed of approximately 7,000 rpm. They can also be used for variable frequency service.

Power ratings of approximately $\frac{1}{100}$ hp can be obtained with the 400 cycle unit. Modifications include high ambient and high altitude versions as well as servo, hysteresis synchronous and gear motors.

Specifications for standard model D 21UHP—1, capacitor run induction motor, are as follows: 115 volts, 400 cycles, single phase, 11,000 rpm, 0.1 amp., $\frac{1}{300}$ hp, 0.1 mfd, 220V., 35 percent efficiency, weight, $3\frac{1}{2}$ ounces.



Eastern Air Devices, 585 Dean St., Brooklyn 17, N. Y.

CONTINUED ON PAGE 238

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. . Mechanisms, Instruments, Electrical Devices?

. . Hydraulic or Pneumatic Components, Motors, Controls?

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Every month Product Engineering lists scores of new catalogs and bulletins available from manufacturers. Some of these cover features of specific equipment. Others contain detailed technical information on selection and application of broad classes of products. All are available to you for the asking.

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Getting all the information about all of the significant new developments in the design field every month is a tough . . . and time consuming . . . job. To save you time, the editors of Product Engineering screen scores of new catalogs and bulletins each month, select only the ones they know will be of interest to you, and summarize each for your convenience. The companies issuing these catalogs welcome your request for copies.

To save you time in making such requests, simply use one of the attached post cards.

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To be sure that your request will receive prompt and careful attention, please write or print legibly your name, company affiliation, and address. This service is valuable to you only if you use it. We welcome your comments and suggestions at any time.

Contact KAYDON of Muskegon

FOR ALL TYPES OF BALL AND ROLLER BEARINGS: 4" BORE TO 120" OUTSIDE DIAMETER

TOP TABLE-SPINDLE DOUBLE-ROW *TAPERED* ROLLER BEARING

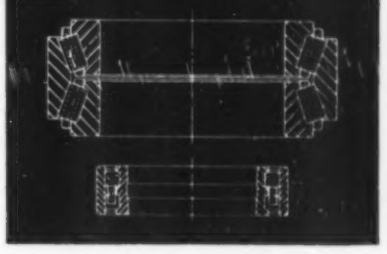
KAYDON Super-Precision Double-Row Preloaded Bearings used in 48-inch Frauenthal "MILLIONTHS-of-an-inch" Grinders

BOTTOM TABLE-SPINDLE DOUBLE-ROW *STRAIGHT* ROLLER BEARING

WHY KAYDON Bearings assure millionths-of-an-inch precision with Frauenthal Grinders

WHAT gives Frauenthal Grinders such dependable super-precision performance? Answer: TWO double-row preloaded KAYDON super-precision bearings! *WHERE?* In the table-spindles of these modern "Millionths-of-an-inch" grinders, one KAYDON double-row *tapered* roller bearing at top of spindle, and one KAYDON double-row *straight* roller bearing at bottom (designed to allow for thermal changes without affecting the upper bearing). Both are preloaded oversize bearings. RESULTS: Super-precision grinders vital to production of much of the modern military and industrial equipment responsible for America's leadership.

For machines you *make* to *sell*, or *buy* to *use*, specify KAYDON Bearings. Contact KAYDON at Muskegon.



Cross-section showing top double-row *tapered*, and bottom double-row *straight* roller bearings, engineered and produced by KAYDON for Frauenthal Grinders.

KAYDON Types of Standard and Special Bearings: Spherical Roller • Taper Roller • Ball Radial • Ball Thrust • Roller Radial • Roller Thrust • Bi-Angular Bearings

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

PRECISION BALL AND ROLLER BEARINGS

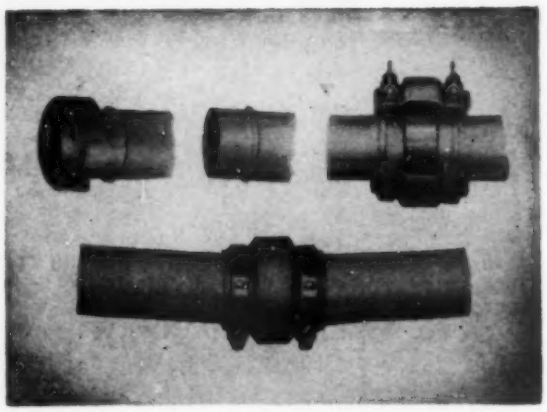
Flexible Fluid Line Connectors For Aircraft

New flexible fluid line connectors for tubing in sizes from 1 to 4½ in. O. D. give a leak-proof seal under extreme temperature range and pressure while allowing maximum misalignment up to 4 degrees. Coupling weight is reduced by up 75 percent, and is quickly assembled as shown.

Top left view shows the beaded tube ends before joining, with the seal assembly, molded from a special compound developed by this company, and applied to one end of the tube. Top right view shows the clamp assembly ready for closing by means of two hose clamps. Bottom view shows the connector clamped into position. Illustrated also is the 4 deg. effective misalignment.

The unit is said to meet all the requirements of NAS512 specification, including fuel resistance, temperature extremes of 160 F to —65 F, and pressures from 160 psi to 28½ inches Hg vacuum.

Rubber Teck, Inc., Gardena, Calif.



Timer Used For Repeat Cycling And Programming

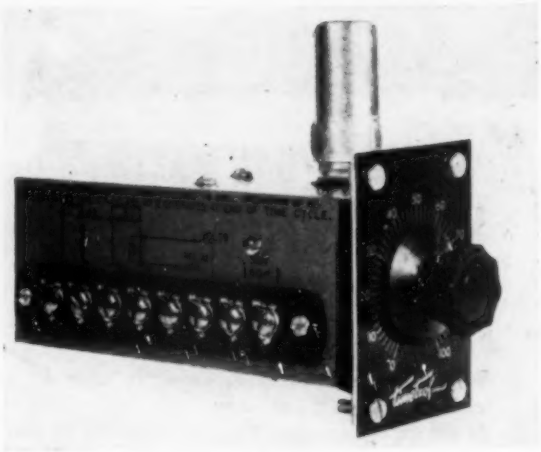
This electronic timer is used to give timed ON periods or timed delay in the range between 0.05 and 20 seconds, and in groups of two or more, it can be used for repeat cycling, programming, or other intricate applications.

The timer has high repeat accuracy, regardless of line voltage variations, tube aging, or temperature change. This is possible because the time interval is determined by a percentage charge on a condenser, which is independent of the applied voltage in an RC network.

The timer includes two fast acting relays; one a "start" relay controlled from an external contact switch which initiates the time cycle, and another energized by the timer after the timed interval.

Other specifications: instant start of each successive cycle once the ten second initial warm-up is completed; less than 1 percent variation in time intervals on successive operations; instantaneous recycling; input 105-130V, 60 cycles.

Timetrol Company, 2191 Gladstone St., Rockford, Ill.



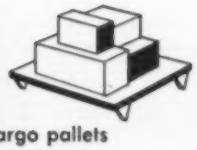
MECHANICAL HIGH VACUUM PUMPS which will pump condensible vapors, such as water vapor, without oil contamination or loss of pumping capacity are available in a single-stage units with capacities ranging from 2 to 400 cu. ft./minute. Compound units (two rotors on the same shaft), are also available with capacities from 2 to 15 cu. ft./min., and in combination units (where two single-stage pumps are combined in series) with capacities from 30 to 400 cu. ft./minute. Called the rotary gas ballast pump, it prevents the condensation of vapors by keeping the vapor pressure of the vapors below their condensation pressures. Power requirements are low. National Research Corp., 70 Memorial Drive, Cambridge, Mass.

MINIATURE GAGE PRESSURE POTENTIOMETERS that are designed for remote measurement of hydraulic and pneumatic pressure in aircraft, guided missiles and other equipment, are actuated by the flexture of an accurately calibrated Bourdon tube, and have a ½ watt electrical output which is linear with the applied pressure. The movement of the Bourdon tube is transmitted to the wiper contact on the wire-wound resistance element by a ball bearing-supported linkage system. Available in ranges from 0-100 psi to 0-5,000 psi. they have a solution of 0.4 percent. A selection of standard resistance values up to 10,000 ohms is available. Instruments are not damaged by shock, vibration, or nominal over-pressure. Bourns Laboratories, 6135 Magnolia Ave., Riverside, Calif.

CONTINUED ON PAGE 240

THE DOUGLAS AIRCRAFT COMPANY ANNOUNCES

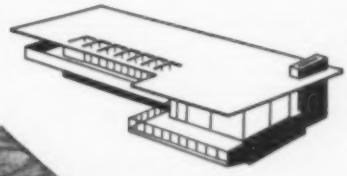
a remarkable new structural material...



Cargo pallets

House trailers

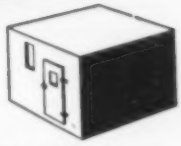
Furniture



Floors, walls, roofs

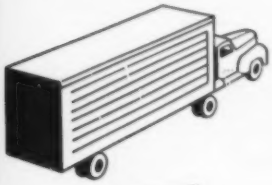
AIRCOMB

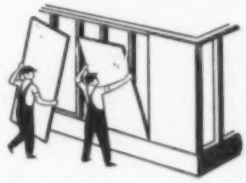
TRADE MARK



Truck bodies, refrigerated or regular

Walk-in refrigerators





Building panels for partitions, etc.

What it is:
AIRCOMB is a honeycomb structure of Kraft paper impregnated with a phenolic resin. In use it is sandwiched between faces of thin material such as aluminum, wood, plywood, stainless steel or magnesium. It is shipped pre-cut in any thickness from 1/16" to 5".

Characteristics:
Properly panelled, AIRCOMB is the strongest material in relation to weight now being manufactured.

It is 16 times as rigid as an equal weight of steel.

It is durable, fire-resistant and pest-resistant.

It has excellent insulation and soundproofing properties.

- Engineering advice on how to adapt this superior structural material to your needs is available.

DOUGLAS AIRCOMB PRODUCT

The use of AIRCOMB instead of heavier materials allows large savings in the cost of manufacturing and shipping your product. For information write to AIRCOMB Section, Douglas Aircraft Company, Inc., Dept. L-3, 3000 Ocean Park Boulevard, Santa Monica, California.

Magnetic Decision Elements

Magnetic decision elements are completely basic, completely flexible building blocks, which, when using only two types, termed "S" and "A", it is possible to build the entire arithmetic, program, control, and memory sections, of any digital computer. This includes both serial and parallel systems, every thing from simple flip-flops and binary counters to large-scale general purpose computers, and digital differential analyzers.

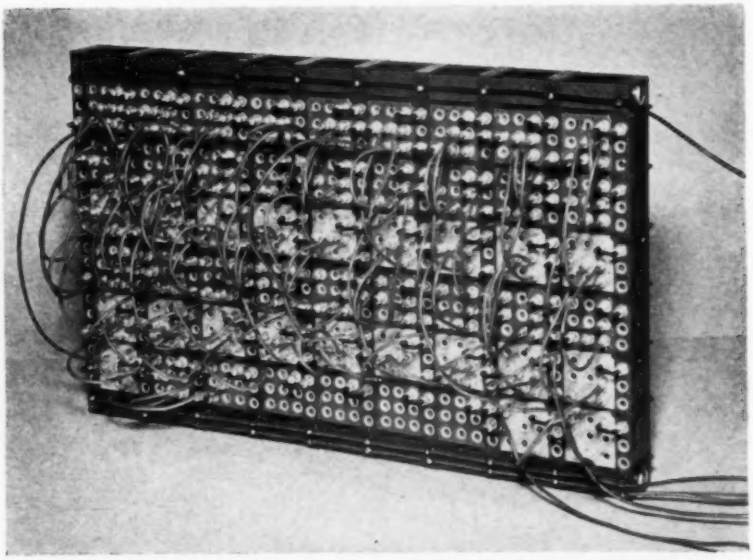
The standard "S" and "A" elements are the same size, one cubic inch, and are designed with interlock connectors for rapid cascading in any desired performance pattern.

The magnetic decision elements contain no electron tubes or transistors. All components are cast in an epoxy type of resin resulting in a rugged structure that operates over wide ranges of temperature, humidity, vibration and shock.

Synchronization and power drive is derived from a central 200-kilocycle two-phase clock pulse generator, and the rate of information flow is 100 kilocycles. Static storage in each element makes it possible to turn the power completely off at any time with suitable clock switching facilities, and retain all the information in the machine indefinitely, including dynamic arithmetic operations.

In addition to their application for end-use equipment, the "S" and "A" elements may be used in research, design and development work involving the empiric evaluation of systems. The manufacturers claim that the cycle of design, use, re-design and reuse in accordance with laboratory or field test technique can be shortened.

The Minnesota Electronics Corp., 47 West Water St., St. Paul 1, Minn.



SWITCH SEGMENTS of silver alloy bonded to a phenolic contact panel are used in a new printed circuit rotary switch with 60 positions, shorting type action. A switch having 30 non-shorting positions is also available. Contact resistance is 0.003 to 0.004 ohms and does not vary more than 0.0003 ohms over the life of the unit. Dia. is 3 in. and depth $2\frac{1}{16}$ in. The Daven Co., 191 Central Ave., Newark, N. J.

A NEW EXTRACTING TOOL that removes threaded broken parts without wedging them into place, is made to work with any fitting in the pipe, hydraulic, aircraft, plumbing, or mechanical fields, and is now available in a range of 20 sizes from $\frac{1}{8}$ to $\frac{7}{8}$ in. by $\frac{1}{32}$ inch. The extractor is designed to form teeth inside the hole until the shoulder contacts the part, and permits a high torque without expanding the part. The large hexagon head of the extractor can be gripped with any wrench. Roddick Tool Co., 1023 N. Pauline St., Anaheim, Calif.

GALVANIZED, SQUARE, RAIL-LOC LOCKNUTS, for use on switches, crossings and trestles in corrosive atmospheres are available in sizes of: $\frac{3}{4}$-10; $\frac{7}{8}$-9; 1-8; $1\frac{1}{4}$-7; $1\frac{1}{4}$-7; and $1\frac{3}{8}$-6. Security Locknut Corp. Melrose Park, Ill.

CONTINUED ON PAGE 242

NEW RYNEL POWER TRANSMISSION DESIGN ENGINEERING SERVICE

GEARMOTORS SPEED REDUCERS *with High Overhung Load Capacities*

Rynel Speed Reducers and Gearmotors are offered in a range from 1/50 to 5 H.P. and 1" to 8" centers, with any desired ratios practical in this range.

Clean-swept modern design, plus gearing built to produce exact rated efficiency makes these Rynel reduction units highly desirable for all critical operating conditions.

DESIGNERS AND SUPPLIERS

Double Reduction
Right Angle
Parallel Shaft
Shaft Mounted
Speed Reducers
and
Gearmotors

MEMBER

AGMA

CALL A RYNEL ENGINEER — *He Will Visit You the Same Day You Call.*

WRITE FOR A COPY
of Complete Bulletin on Sizes and Types of RYNEL Reduction Units
Ask For Bulletin

RYNEL CORPORATION

Phone Sterling 4440 • **712 Miller Street, Sterling, Illinois**

Chicago LOngbeach 1-7111 • **4730 N. Western Avenue, Chicago, Illinois**

SPUR - HELICAL - WORM - WORM GEAR - INTERNAL SEGMENT - RATCHET - STRAIGHT BEVEL GEARS

Electronic Relay Has High Resistance Sensitivity

Highly sensitive to resistance changes, a new electronic relay can be varied by a stepless dial, and may be used to start or stop a fractional horsepower motor directly when a contact making ammeter, voltmeter, or wattmeter reaches a required meter reading. Other uses include liquid-level control, sorting of small parts, and operating of lights, solenoids, and contactors wherever there is sufficient change in the resistance of a circuit.

Two single-pole double-throw contacts permit control of independent systems, and a simple jumper change sets the relay for normal or reversed operation. Selection of the most favorable relay operating point is simplified through a sensitivity dial located on the front of the unit. The dial may be remotely controlled from as far away as 500 feet, and may be locked when set.

Power requirements are 115/230 volts a-c, 50/60 cycles, and should not exceed 10 volts amperes. The contact rating is: inrush 30 amps, carry—10 amps, break—10 amps on normally closed contacts, and 5 amps on normally open contacts. The break inductive load for 125 volts d-c is 0.2 amp normally open and 0.1 normally closed; for 250 volts d-c, it is 0.1 normally open and 0.05 normally closed. The time delay, depending somewhat on the dial setting and external resistance value, is rated at 5 milli-seconds minimum.

The new electronic relay enclosure is both weather resistant and dust tight (NEMA Type III and V), making it suitable for both indoor and outdoor installations. The enclosure measures approximately 10 x 6¼ x 4⅞ inches.

General Electric Co., 1 River Rd., Schenectady 5, N. Y.

Self-Aligning Nut Has Self-Locking Feature

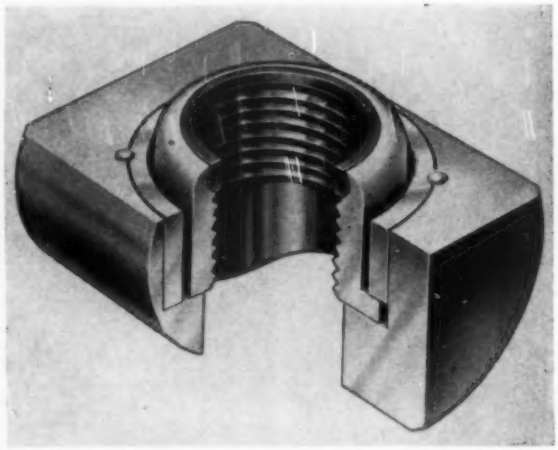
A lightweight, high strength, self-aligning barrel nut with a self locking feature (as shown in the illustration), has been designed for application where highly concentrated loads are encountered.

Called the series SL6, the new nut is manufactured in three pieces: a 75ST6 aluminum barrel; a threaded steel bushing; and a steel retainer. The ears on the base of the threaded steel bushing float in the slotted section of the retainer, making the self-aligning feature, and the knurled retainer is pressed in place and punch staked at four places. The shape of the lightweight barrel distributes the load carried by the steel threads of the bushing into the surrounding structure, permitting use where heavy structural loads are encountered.

The nut is available with internal thread sizes from ¼-28 up to ⅞-14.

The self-aligning feature is said to permit easy mating, prevent cross-threading, permit lower cost tooling, and reduce rejects and scrapping of misfit parts. The manufacturers claim that the SL6 barrel nut weighs approximately 60 percent as much as the same size standard barrel nut, with this weight-saving making it applicable for aircraft use on heavily loaded fittings, engine mounts, and wing joints.

Installation and replacement is fast and easy. For installation, a hole is reamed into the structure, and the barrel nut inserted into the hole. A retaining spring is then snapped into the hole behind the nut.

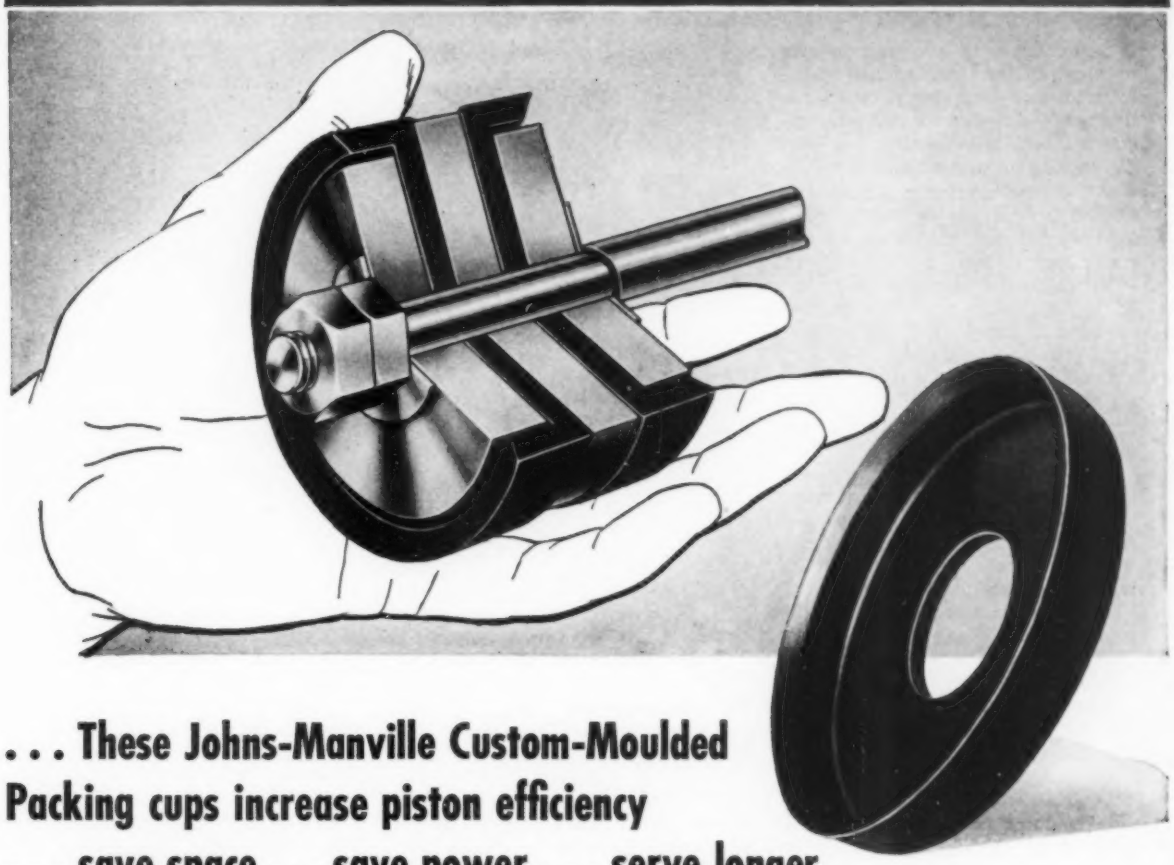


For more information on this line and other types of nuts, write to the manufacturer.

Shur-Lok Corp., 9010 Bellanca Ave., Los Angeles 45, Calif.

CONTINUED ON PAGE 244

Looking for a more efficient piston design?



. . . These Johns-Manville Custom-Moulded Packing cups increase piston efficiency . . . save space . . . save power . . . serve longer

TYPE A . . . The Type "A" J-M Moulded Packing Cup is the "standard" for use on the pistons of pumps and on various hydraulic and pneumatic mechanisms. The lip forms a tight seal under discharge pressure, but relaxes on the reverse stroke, reducing friction and conserving power.

TYPE B . . . This type of cup is essentially the same as Type A, except that the leading edge of the lip is square instead of beveled. This construction provides greater strength where the lip may be exposed to distortion or excessive wear due to openings in cylinder walls.

Johns-Manville Moulded Packing Cups can help you improve piston designs. They provide a highly efficient seal . . . improve equipment performance . . . lower operating and maintenance costs. These custom-made packings are extensively used on all types of slow moving pistons and rams operating under high or low pressures and temperatures.

Johns-Manville Moulded Packing Cups may be used on practically all air or hydraulic-operated cylinders. For instance, those which are in such equipment as reciprocating pumps, hydraulic jacks and presses, pneumatic chucks, governors, lift trucks, grease guns, valves, drilling and boring machinery . . . or on any other equipment where efficient piston design is essential.

You have your choice of a number of styles and compositions of these precision-moulded cups to meet temperatures and pressures encountered in hydraulically operated equipment. Types "A" and "B," shown here, are most widely used on inside-packed pistons with the outside edge or lip contacting the cylinder wall or liner. Other types are available, however, for other services.

If you would like more information on these or other types of Johns-Manville Custom-Made Piston Packings, get in touch with your Johns-Manville Packings Distributor, or write Johns-Manville, Box 60, New York 16, N. Y.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville PACKINGS & GASKETS

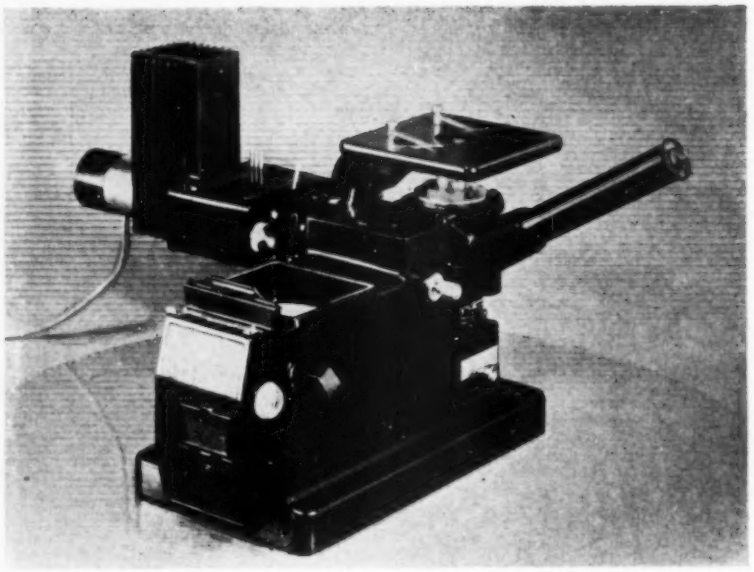
Small Unit Handles All Routine Metal Studies

Occupying only one-tenth to one-twentieth of the space normally taken by instruments used for this type work, this newly designed metallurgical microscope and metallograph will handle routine microscopy and metallography, and will permit group observation of the specimen by projecting the light beam through the camera housing onto a screen.

By using the inverted design, all operations are confined to an area of 13 x 8 x 8 inches. An inclined eyepiece tube permits observation from a seated position, and a slight pull on the mobile prism knob directs the light path to the camera screen at the left of the instrument.

Called the CSF, it has sharp, visual observation at all magnifications up to 1000X, and photographic and projection observation up to 1500X. A 2½ x 3½ in. reflex camera is supplied which takes both plates and roll film.

The CSF has two dry objectives for low and magnifications, and one oil immersion objective for high magnifications. All are individually mounted and centered on interchangeable slide holders. They are supplied in the standard magnifications of 50X, 75X, 100X, 200X, 500X, 1000X and 1500X. Intermediate values are available. A large size square stage is located above the objective which has both a rack and pinion device for coarse focusing, and a micrometric movement for fine focus registering to two microns.



Seven interchangeable photographic lenses are supplied to cover the full range of magnifications up to 1500X. Exact focusing of the reflex camera is done on a horizontal ground glass screen, and the shutter provides time, bulb and wide range of exposure from one second to 1/250th of a second. Photographs on plate or film are taken by raising the reflecting mirror and releasing the shutter.

A 30 watt Concentrated filament low voltage bulb enclosed in a finned housing and an aspherical condenser supply the light source. Hinged interchangeable color filters and a transformer to supply low voltage current are built into the instrument. An opaque illuminator of the thin plane parallel plate type, with an angular mirror, permits the use of both normal bright field objectives and the special objectives for reflected-light dark-field observation.

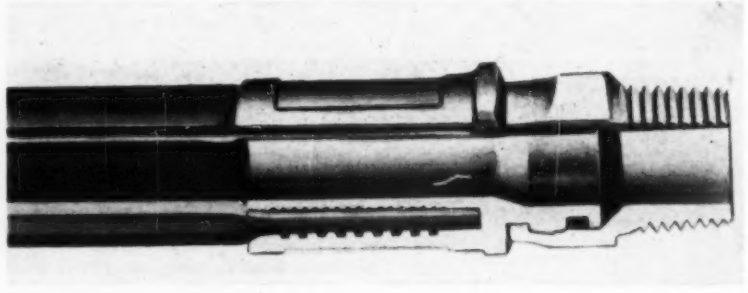
Opplem Co., 352 Fourth Ave., New York 10, N. Y.

Flexible Hydraulic Hose Has High Burst Strengths

Flexible hose with new full-flow fittings for application in medium-high pressure hydraulic systems are being offered in ¼, ⅜, and ½ in. I.D. sizes. According to the manufacturer, this is the first time a non-metal reinforced hose has been able to offer working pressures in the 1800 to 2300 psi range.

This is accomplished by using a tough compar tube and high tensile synthetic fibre-braid carcass. Compar also makes the hose impervious to hydraulic oils. In addition, the all-synthetic construction makes the hose assemblies fatigue-proof.

Physical pull strengths for the ¼, ⅜, and ½ in. hose are given as 900, 2500, and 3500 pounds respectively.



The manufacturers claim that the newly designed fittings for the assemblies do not pull out under these tensions. These assemblies are applicable to hydraulic systems of farm implements, materials handling trucks, implements, materials handling trucks, construction machinery, and other equipment.

Resistoflex Corp., Belleville 9, N. J.

CONTINUED ON PAGE 246

NEW TRACK-TYPE 2-YARD UNIT has Great Flexibility of Service

New advantages in digging, lifting, carrying and dumping are built into the new Caterpillar No. 6 Shovel. Balance, stability, high mobility and flexibility of service give it a wide range of usefulness.

The same quality characterizing its performance has been built into the Federal-Mogul cast bronze bushings designed and manufactured especially for this unit.

FEDERAL-MOGUL CORPORATION, 11043 Shoemaker, Detroit 13, Mich.

FEDERAL Mogul

Since 1899

Sleeve bearings in a wide range of designs and sizes; cast bronze bushings; rolled split-type bushings; bimetal rolled bushings; washers; spacer tubes; precision bronze parts and bronze bars.

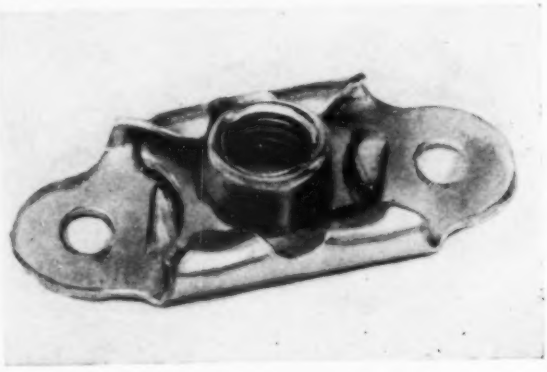
FEDERAL-MOGUL

New Line Of Floating Anchor Nuts

Producers of a new line of light-weight, high-strength, self-locking, nuts and gang channel, have recently developed the new F-5000 series, a 2-lug floating anchor nut in the 10-32 and ¼ in.-28 tap sizes. This series uses the same locking device introduced with the original line of self-locking nuts, and are made to confirm with the AN-N-5b and AN-N-10a specifications of the aviation industry.

Made of spring steel and light in weight, the new series anchor nut is completely interchangeable with fixed type anchor nuts. The full 1/16 in. radial float aids production, and eliminates alignment problems. In the 10-32 tap size, torque-out values in excess of 80 in.-lb., and push-out valves in excess of 400 lb. are attained. In the ¼ in.-28 tap size, torque-out values in excess of 120 in.-lb. and push-out valves in excess of 500 lb. are attained.

Because of its all metal construction, the anchor nut can be used in applications up to 550 degrees. Parts are normally furnished cadmium-plated, but are available in several other finishes for special applications.



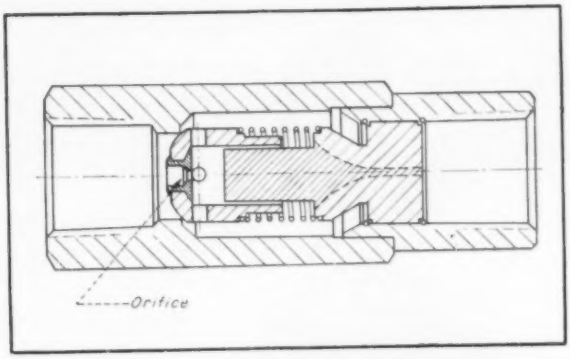
The Kaynar Co., 820 E. 16*th* St., *Los Angeles, Calif.*

Non-Adjustable Restriction Valves

Developed to regulate the speed of a cylinder in one direction, a new line of non-adjustable restrictor valves has been designed having a check valve with an orifice in the check poppet, with the size of the orifice made to suit the application. This is determined by the flow desired at any given pressure.

Free flow is permitted in one direction by the check valve; reverse flow closes the check and the flow must pass through the orifice. Low pressure drop in the free flow direction is obtained by using standard check valve parts. These valves are made with large seats and flow areas.

This valve is normally furnished with a one-piece copper-brazed steel body, but aluminum bodies can be furnished. The one-piece body eliminates gaskets and gasket leakage, and the valve cannot come apart when pipe or fittings are removed. Burst pressures exceed 10,000 psi. Sizes available are ¼ in., ⅜ in., ½ in. and ¾ in. pipe.



Fluid Controls, Inc., 1284 *North Center St., Mentor, Ohio*

SMALL SPEED REDUCERS, measuring only $2\frac{7}{16}$ in. high and $2\frac{3}{8}$ in. wide, are nominally rated at $\frac{1}{10}$ hp, and are available in over 600 different ratios. Typical applications are for chart drives, computers, oscillographs, and servomechanisms. Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.

A NON-FADING, CORROSION RESISTANT organic finish is now being applied to aluminum, brass, steel, and zinc coils in widths from ⅛ to 30 in., 0.010 to 0.036 in. gage, in continuous lengths. This baked enamel type finish will stand up during the forming, drawing, and fabricating of the metal. Apollo Metal Works, 66th Place & S. Oak Park Ave., Chicago 38, Ill.

DESIGNED WITH A SPECIAL VACUUM SWITCH to guard against burn out when the liquid supply runs dry, a portable pump for industrial, farm, marine, and home use will lift water up to 10 ft unprimed, 22 ft primed, and has a capacity of up to 5 gal per min with up to 30 psi. Hypro Engineering, Inc., 404 N. Washington Ave., Minneapolis, Minn.

FOR PRESSURE AND DYNAMIC SEALING, eighty-seven stock sizes of O-rings, from ⅛ x ¼ x $\frac{1}{16}$ in. to 15½ x 16 x ¼ in. for either moving or non-moving seals, plus 52 additional listings recommended for non-moving sealing applications only, are now available for automotive, aviation, and machinery industries for original equipment and replacement. The rings are made of a synthetic rubber compound developed by the manufacturer. Compounds for special conditions are available. Victor Mfg. & Gasket Co., P. O. Box 1333, Chicago 90, Ill.

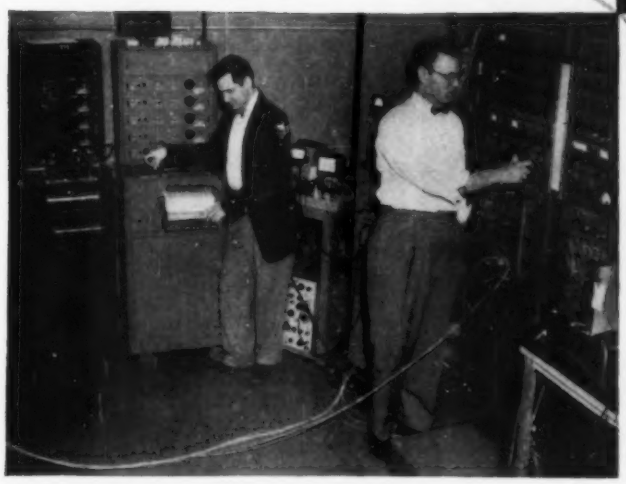
CONTINUED ON PAGE 248

SANBORN OSCILLOGRAPH RECORDING SYSTEMS HAVE MANY APPLICATIONS

Sanborn Recorders Help Speed Flight Design

SPERRY GYROSCOPE COMPANY uses a two-channel Sanborn Recording System for basic research on their Zero Reader* Flight Director, a device which simplifies the manual control of aircraft. The Sanborn System shown above is recording the output of a flight simulator that solves Zero Reader equations.

*T. M. REG. U. S. PAT. OFF.



At McDONNELL AIRCRAFT CORPORATION the movements of a guided missile are simulated by high-precision analog computers which in turn send *eight* different resultant electric signals into two Sanborn four-channel Recording Systems (left) for the graphic recording of the hypothetical results of the guided missile problem.

At DOUGLAS AIRCRAFT COMPANY'S Flight Test Section, a Sanborn two-channel Recording System (shown removed from case for field operation) is used in conjunction with a telemeter radio link to record surface motion vibration in a flying aircraft while it is performing tests requiring continual monitoring. Recorded tracings provide the necessary permanent visual time history for comparison of the two events recorded and a study of their individual characteristics.

How can Sanborn help you?

Sanborn one-, two-, and four-channel Recording Systems can provide an accurate and permanent graphic registration of almost any electrical phenomena whose frequency spectrum falls within the range of zero to 100 cycles per second. The availability and ready *interchangeability* of amplifiers and preamplifiers offer a wide range of use.

Records are traced by heated stylus on plastic coated strip-chart paper, and are in true rectangular coordinates. Other Sanborn advantages include: a high torque movement (200,000 dyne cms per cm deflection); built-in code and time markers; and a wide choice of paper speeds and channels.

Sanborn engineers will be pleased to make recommendations as to what type of equipment will best solve your recording problem. When writing, include the lower and upper limits and the frequency range of the phenomena to be recorded, and the type of transducer.

Ask for a copy of our "Applicability Folder" which presents a table of uses, complete performance data and specifications, brief descriptions of Sanborn Recording Systems and explanations of how their amplifiers may be readily interchanged.

SANBORN CO. INDUSTRIAL DIVISION
CAMBRIDGE 39, MASSACHUSETTS

WITH STAR-KIMBLE BRAKEMOTORS

Stopping of a Star-Kimble Brakemotor is split-second in action, precisely timed by simple adjustments. Quiet, too — no lining screech. Low lining pressure, evenly distributed, assures long brake life. Brake is self-adjusting to compensate for lining wear — ruggedly built to withstand shock and vibration.

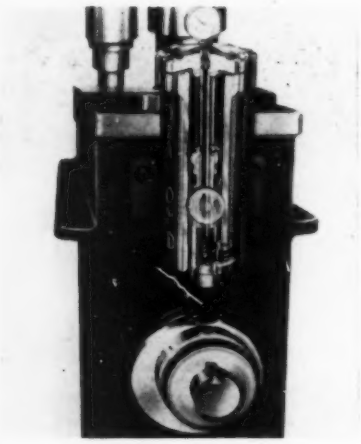
Braking force is spring applied, magnetically released. No linkages to cause lost motion or friction.

Starting of a Star-Kimble Brakemotor is smooth and free from drag. Small magnetic air gap assures quick brake release without high inrush current.

And Star-Kimble Brakemotors *maintain* this fast, smooth stop-start operation through millions of cycles with little or no maintenance attention. Brake and motor are *designed* together to *work* together as a single compact unit. One manufacturer, one responsibility — backed by years of experience. For details on construction, motor ratings and braking torques, write for Bulletin B-501-A.

Standard and special motors of all types, 1 to 600 hp; Marine motors ½ to 600 hp; generators and motor-generator sets, 1 to 500 kw.

STAR-KIMBLE
MOTOR DIVISION OF
KIMBLE PRINTING PRESS AND MFG. CO.
211 Bloomfield Avenue Bloomfield, New Jersey



Pneumatic Clutch Equilibrator

This new clutch equilibrator is a two-part unit consisting of a heart shaped cam and an air chamber with an automatic pumping and regulating mechanism. This development, as used on punch presses, counter-balances the variable punch and die plates which vary from one setup to another, acts as a frictionless brake, and removes all the load from the clutch assembly at the time of disengagement.

The "heart" designed cam is installed on the crankshaft and secured to the face of the brake drum. A roller rides on the surface of this cam, and counterbalances the ram weight. At up stroke of ram, the roller pressure on the surface of the cam rotates the crankshaft approximately five degrees ahead of the bull gear wheel. At the point of clutch disengagement this pre-rotation eliminates all drag and pressure on the length of the clutch dog, and makes for easy clutch engagement and disengagement.

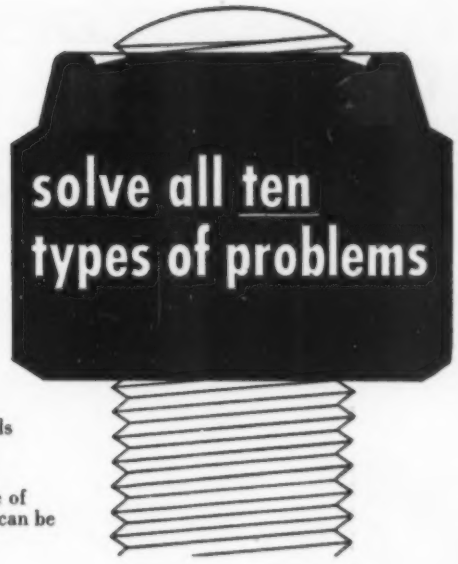
The Diamond Machine Tool Co., Pica, Calif.

Portable Force Metering System

Calibrated linear thrusts of up to 50 tons in any direction can be applied with a new portable force metering system that exactly weighs the force as it is applied. The force is exerted by a hydraulic jack, mounted on a high precision hydraulic cell. The ouput of the cell is connected to a load indicator which reads the load in pounds, kilograms, or any arbitrary units. The unit is completely portable, and does not require a special foundation, compressed air, or electric power.

Four cell sizes and three indicator

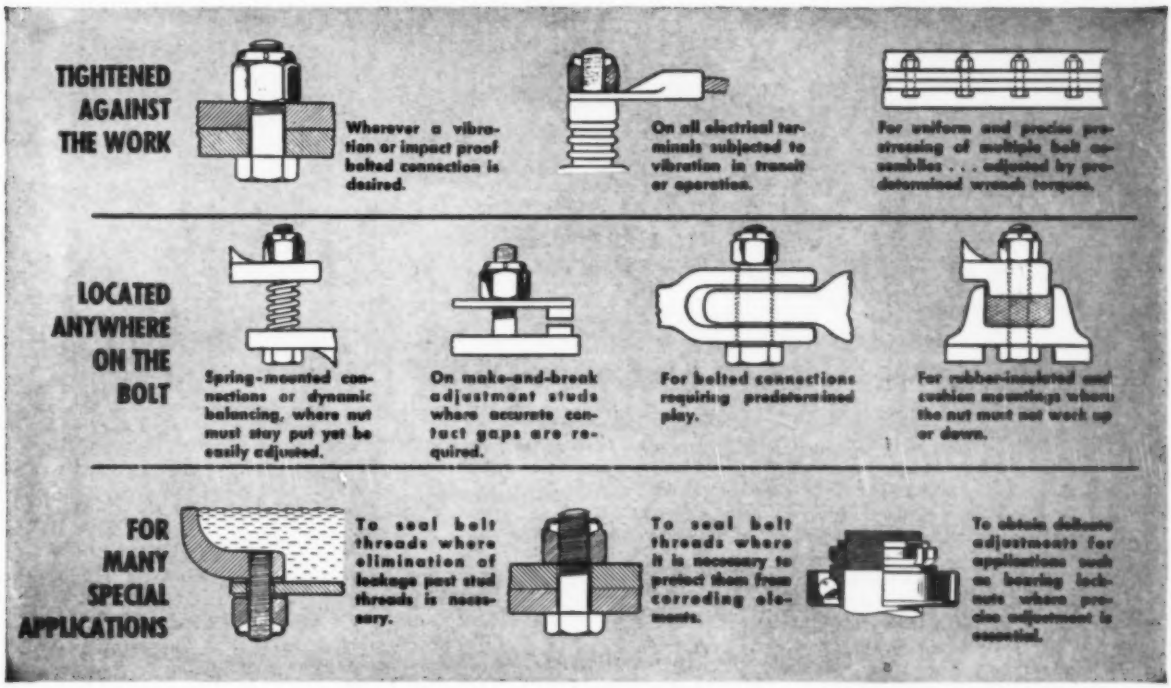
elastic stop nuts solve all ten types of problems



Here are ten typical fastening problems. One device, the ELASTIC STOP nut, solves them all—without additional parts or operations. Deliberately undersized in relation to bolt diameter, the red elastic collar grips the bolt with a perfect fit, exerting a continuing self-locking pressure against the threads, and holding the nut securely in place at any point on the bolt. It also provides a tight seal against the bolt threads, which prevents seepage and wear-producing axial play. And because the bolt threads are protected against moisture from without, the nuts are not "frozen" to the bolt by corrosion.

ELASTIC STOP nuts stay tight, right where you put them, in spite of vibration and stress reversals. Yet they are not jammed in place, and can be removed with a wrench and reused many times.

For further information on ESNA self-locking fasteners, mail the coupon below.


TIGHTENED AGAINST THE WORK
Wherever a vibration or impact proof bolted connection is desired.
On all electrical terminals subjected to vibration in transit or operation.
For uniform and precise prestressing of multiple bolt assemblies . . . adjusted by predetermined wrench torques.
LOCATED ANYWHERE ON THE BOLT
Spring-mounted connections or dynamic balancing, where nut must stay put yet be easily adjusted.
On make-and-break adjustment studs where accurate contact gaps are required.
For bolted connections requiring predetermined play.
For rubber-insulated and cushion mountings where the nut must not work up or down.
FOR MANY SPECIAL APPLICATIONS
To seal bolt threads where elimination of leakage past stud threads is necessary.
To seal bolt threads where it is necessary to protect them from corroding elements.
To obtain delicate adjustments for applications such as bearing locknuts where precise adjustment is essential.

ELASTIC STOP NUT CORPORATION OF AMERICA

ESNA TRADE MARK

ROLLPIN TRADE MARK

Dept. N40-92, Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, New Jersey

Please send the following free fastening information

☐ Elastic Stop nut bulletin ☐ Here is a drawing of our product. What self-locking fastener would you suggest?
☐ Rollpin bulletin

Name_____ Title_____

Firm_____

Street_____

City_____ Zone_____ State_____

SHOCK – VIBRATION – NOISE

ISOLATION NOTES

These **NEW** *Product Bulletins give* **YOU**

COMPLETE ENGINEERING DATA on ALL-METL BARRYMOUNTS

Here's what's in them for **YOU:**

1. Transmissibility curves showing performance under test conditions of JAN-C-172A.
2. Curves showing reduction of transmitted acceleration and displacement.
3. Curves showing how changes in loading affect transmissibility at resonance and natural frequency for vertical motion.
4. Curves showing effect of high and low temperature on isolator performance.
5. Shock-characteristic data, including curves showing vibration isolation after 15g shock test.
6. Application data, including curves that show you how to choose isolators for unsymmetrical loads.
7. Dimensioned drawings of unit isolators, channel pairs, and mounting bases.
8. Detailed data on the construction, operating principle, and weights of mounts and bases.
9. A complete list of load ratings and catalog numbers for unit isolators, channel pairs, and bases.

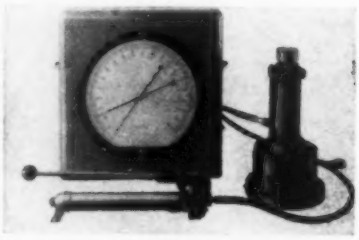
These are the first really comprehensive bulletins on knitted-wire vibration isolators. To get your FREE copies, ask for Barry Product Bulletins 534 and 536. *And, if you have a special problem, count on getting the right answer from our Field Engineering Service.*

THE **BARRY** CORP.

730 PLEASANT ST., WATERTOWN 72, MASSACHUSETTS

SALES REPRESENTATIVES IN

Atlanta Baltimore Chicago Cleveland Dallas Dayton Detroit Los Angeles Minneapolis New York Philadelphia Phoenix Rochester St. Louis San Francisco Seattle Toronto Washington



sizes permit the choice of the most efficient system. Indicators are calibrated from 0-500 to 0-100,000 pounds. Accuracy of each unit is within 0.25 percent of full scale.

This calibrated thrust system permits direct weighing of bridge, structure, and other large loads, and the application of an exact force at any point.

The A. H. Emery Co., New Canaan, Conn.

Adjustable Engineers Protractor

Any number of angles, from zero to 180 deg., can be drawn with a new adjustable protractor without sliding or moving the protractor out of position. The upper rule arm is moved to the desired angle and locked in posi-

tion. A magnifier, built-in over the registration mark, gives accurate adjustment. The 180 deg. arc is calibrated in 1 deg. and 5 deg. divisions. The device measures 2 in. wide and 7 in. long when set at zero.

Way-Mac Mfg. Co., 8112 Melrose Ave., Los Angeles 46, Calif.

High Tensile, Porous Stainless Steel Filters

Porous stainless steel filter sheet, a new type designated grade X is said to be distinguished from previously available materials by an approximately doubled tensile strength, a smooth surface, and by a close control of thickness. Tensile strength of the porous

material is in the neighborhood of 25,000 lbs./inch. The porous sheet is also said to be more ductile than previously available porous stainless steel sheet material. This material is now available in the form of finished line filters. Thickness tolerances are maintained to plus or minus 0.002 inch.

Sheet material is now available in 0.040 in. thickness, with a mean pore opening of 10 microns. Other thicknesses ranging from 0.020 in. up to $\frac{1}{8}$ in. are also available.

Micro Metallic Corp., 35 Sea Cliff Ave., Glen Cove, N. Y.

Liquid Level Maintained Automatically

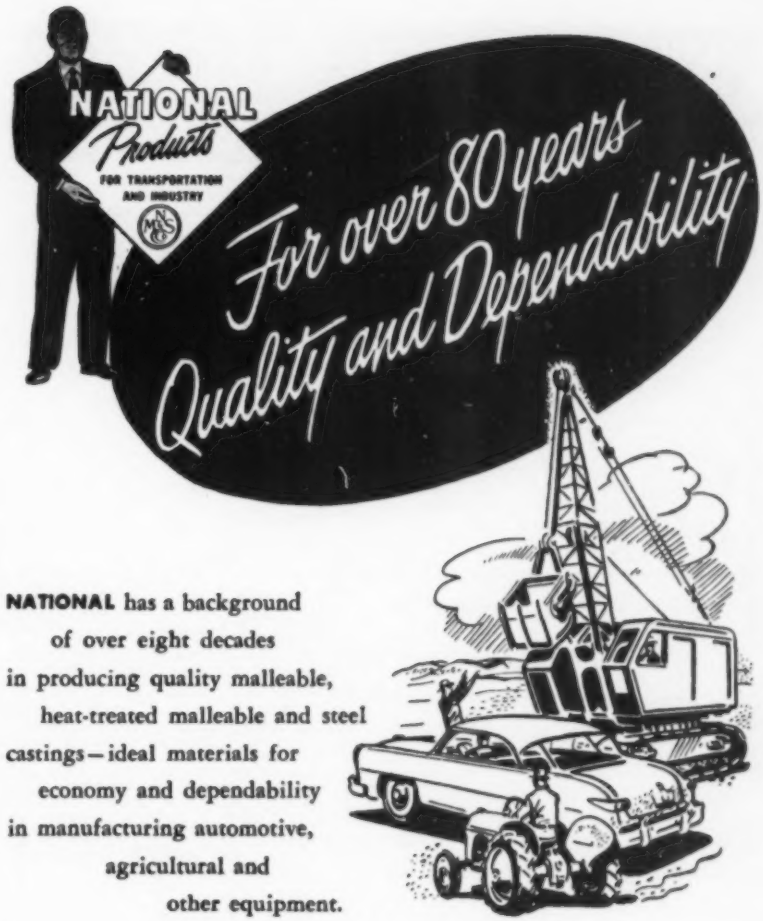
Known as the automatic liquid level control, this pressure reduction valve has been designed to maintain a low and sensitive outlet pressure, and can be adapted to many uses where a steady water or other liquid level is to be maintained automatically. It can

take the place of float valves, wherever a closed system is necessary because of sanitary requirements or corrosive conditions. The control operates in a range of inlet pressure from 5 psi to 260 psi, and can be set to maintain a steady water level in a range from 5 to 20 inches.

Helco Products Corp., 2041 Colorado Ave., Santa Monica, Calif.

Powder-Metal Impellers Used In Oil Pump

Made from sintered bronze metal powder, the two impellers of this small positive displacement delivery pump absorb the oil being pumped, thus minimizing the dangers of heat seizures and scorched impellers. Used primarily for the pumping of all types of oils and greases, the pump has a



NATIONAL has a background of over eight decades in producing quality malleable, heat-treated malleable and steel castings—ideal materials for economy and dependability in manufacturing automotive, agricultural and other equipment.

NATIONAL's unparalleled experience—coupled with a continuing metallurgical research program, rigorous quality control standards, and completely mechanized foundries in strategically located cities—is at your disposal.

Sales offices and engineering facilities are located at all five plants listed below.

A 16mm Technicolor film. Narrated by Edwin C. Hill, this 27-minute film tells how malleable iron is made . . . tested . . . used . . . how its production economy, ductility, machinability, toughness will give you a better finished product. Available for group showings. A-5017

PLANTS LOCATED IN
Sharon, Pa., Cleveland 6, Ohio, Indianapolis 6, Ind., Melrose Park, Ill., and Chicago 50, Ill.

NATIONAL Products FOR TRANSPORTATION AND INDUSTRY Est. 1868

NATIONAL MALLEABLE and STEEL CASTINGS COMPANY
CLEVELAND 6, OHIO

INDEX OF ACP CHEMICALS FOR METAL PRESERVATION AND PAINT PROTECTION

METAL	OPERATION	ACP CHEMICAL
ALUMINUM	Cleaning	"DEOXIDINE" "DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Preparation for Painting	"ALODINE" "DURIDINE" "DEOXIDINE"
	Protection from Corrosion	"ALODINE"
GALVANIZED IRON, ZINC, AND CADMIUM	Cleaning	"DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Corrosion Proofing	"ZINODINE"
	Paint Bonding	"ZINODINE"
	Phosphate Coating, in Preparation for Painting	"LITHOFORM"
	Soldering Flux	"FLOSOL"
STEEL	Chromate Coating, in Preparation for Painting	"CROMODINE"
	Cleaning	"ACP RIDOLINES AND RIDOSOLS"
	Cleaning for Painting	"DEOXIDINE" "DURIDINE"
	Coating with Copper	"CUPRODINE"
	Drawing and Extrusion	"GRANODRAW"
	Paint Bonding	"CROMODINE" "DURIDINE" "GRANODINE" "PERMADINE" "THERMOIL-GRANODINE"
	Paint Stripping	"CAUSTIC SODA AND SOLVENT NO. 3"
	Phosphate Coating, in Preparation for Painting	"DURIDINE" "GRANODINE" "PERMADINE" "THERMOIL-GRANODINE"
	Phosphate Coating, to Protect Friction Surfaces	"THERMOIL-GRANODINE"
	Pickling with Inhibited Acids	"RODINE"
	Rust Prevention for Unpainted Iron	"PEROLINE"
	Rust Proofing	"PERMADINE" "THERMOIL-GRANODINE"
	Rust Removal—Brush, Dip, or Spray	"DEOXIDINE"
	Soldering Flux	"FLOSOL"

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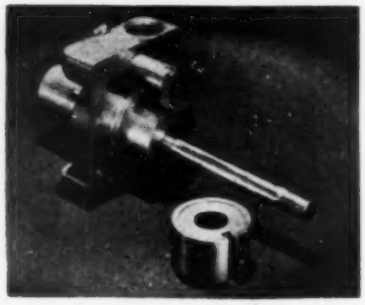
CHEMICALS ACP PROCESSES

AMERICAN CHEMICAL PAINT COMPANY

GENERAL OFFICES: AMBLER, PENNSYLVANIA

Detroit, Michigan Niles, California Windsor, Ontario

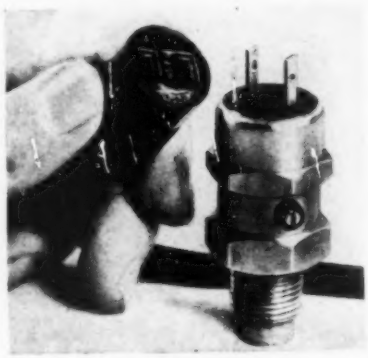


maximum capacity of 10 gpm, and is suitable for pumping oil at temperatures up to 500 F. It is self-priming in low-temperatures, has good suction, may be operated submerged, and will pump in either direction and in any position.

Eco Engineering Co.,
12 New York Ave., Newark, N. J.

Miniature, Screw-In Type Thermal Switch

A thermal switch of the cartridge type, operating with a bimetallic element, may be set to function at temperatures as high as 300 F. The switch measures 2¼ in. in length by 1⅛ in. overall in dia., and is made



to screw into a ⅜ in. hole in the equipment housing of pumps and similar equipment.

Possible applications are with: hydraulic and vacuum pumps; gas and diesel engines; air compressors; bearings of all types; large electric motors; and various machines.

Eco Engineering Co.,
12 New York Ave., Newark 1, N. J.

Solenoid Actuated Relay

Compact, lightweight, high G relays have been developed to satisfy AAF and MIL specifications of high and low temperature, materials, insulation, vibration, shock, and accelera-

Specify

GITS *Unit* SEAL

Result:

Economy

"Economy . . . counts not in savings but in selection." —*Edmund Burke*

Economy through Efficiency

Gits Unit Seal proves itself in dependable performance over a wide range of operating conditions—including extra-high speed, heat and pressure applications. Operation at peak efficiency always means dollars-and-cents savings.

Economy through Adaptability and Versatility

Gits Unit Seal fits many applications as a standardized item actually carried in stock. You harness the savings of mass production to your own specific needs. Gits Unit Seal already has wide application in the following fields: Washing Machines, Disposal Units, Gear Motors, Speed Reducers, Aircraft Turbine Pumps, Accessory Drive Units, Jet Propulsion Units, Electrical Power Equipment, Automotive Accessories, Business Machines, Standard and Special Machine Tools.

Economy through Long Life

Gits Unit Seal is designed for maximum life in any recommended application. Here's the real "proof of the pudding" in saving money.

Write Today For FREE Illustrated Brochure, or send us your seal problem. Our experienced engineering staff is at your service.

*Cartridge Seal . . . requiring only 25% more space than lip-type seals.

GITS BROS. MFG. CO.

1838 S. Kilbourn Avenue — Chicago 23, Illinois

GRAPHALLOY
TRADE MARK REG. U. S. PAT. OFF.

OIL-FREE
SELF-LUBRICATING
BUSHINGS

"WORK WHERE OTHERS WON'T"

Widely Used Where Ordinary Oil Lubrication Is Impractical or Impossible.

EXCELLENT DURABILITY • CONSTANT CO-EFFICIENT OF FRICTION • APPLICABLE OVER A WIDE TEMPERATURE RANGE — EVEN WHERE OIL SOLIDIFIES OR CARBONIZES **• OPERATE DRY, OR AT HIGH SPEEDS SUBMERGED IN WATER, GASOLINE AND OTHER LIQUIDS • EXCELLENT FOR CURRENT-CARRYING BEARINGS**

GRAPHALLOY materials are also in wide use for oil-free, self-lubricating piston rings, seal rings, thrust washers, friction discs, pump vanes etc.

OTHER GRAPHALLOY PRODUCTS

BRUSHES

CONTACTS

For applications requiring low electrical noise, low and constant contact drop, high current density and minimum wear. Used for SELSYNS, DYNAMOTORS, SYNCHROS, ROTATING STRAIN GAGE pick-ups and many other applications. Brush Holders and Coin Silver Slip Rings also available.

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1012 NEPPERHAN AVENUE • YONKERS, NEW YORK

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☐ Send data on BRUSHES and CONTACTS.

NAME & TITLE
COMPANY
STREET
CITY ZONE STATE

tion requirements. They are available with a choice of 4 precision switches: SP-NC; SP-NO; SPDT (AN3210-1); and SPDT split contact (AN3216-1).

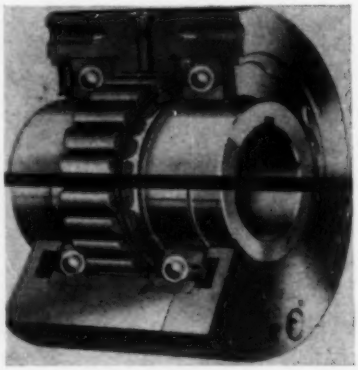
Coil data: nominal voltage 24-28 v d-c; maximum operating voltage 29 v d-c; pickup voltage 18 v d-c; dropout voltage 1.5 v d-c; standard coil 160 ohms; max. coil current 0.180 amp; with other coils available. Operating cycles: 25,000 minimum. Dimensions: $2\frac{1}{16}$ x $1\frac{9}{16}$ x $2\frac{5}{16}$ inches.

Electrical Products Corp., 110 N. Main St., Los Angeles, Calif.

Over-Running Clutches Operate At Higher Speeds

Over-running clutches can operate at speeds in excess of 3,000 rpm, with a new centrifugal throwout sprag assembly that prevents any possible rubbing between the sprags and the inner race. This new feature is available in the all-purpose ball bearing clutch, a standard model with eight possible variations.

Construction of clutches consists of only four basic parts: the outer housing; the inner race; a full complement of sprags; and the energizing springs. The sprag principle (with its full complement feature) has an unlimited number of gripping positions and



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Since 1919 Curtis has concentrated on the manufacture of only one line. As a result, Curtis research, production and quality control techniques have produced the widely accepted Curtis standards—and the world's best universal joint.

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Quality Standards — Curtis Joints set the standards for the industry.

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UNIVERSAL JOINT CO., INC.
11 BIRNIE AVENUE
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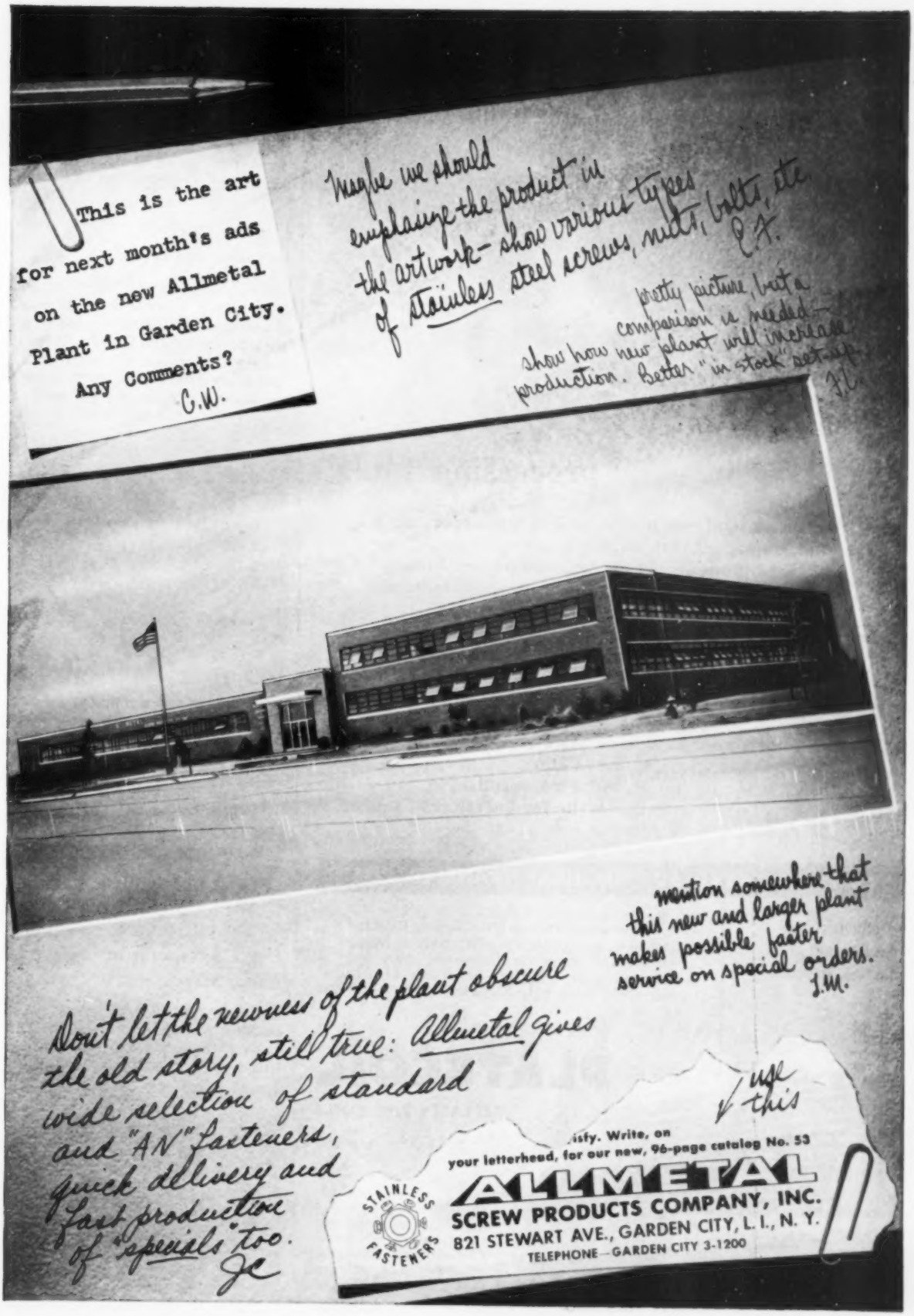
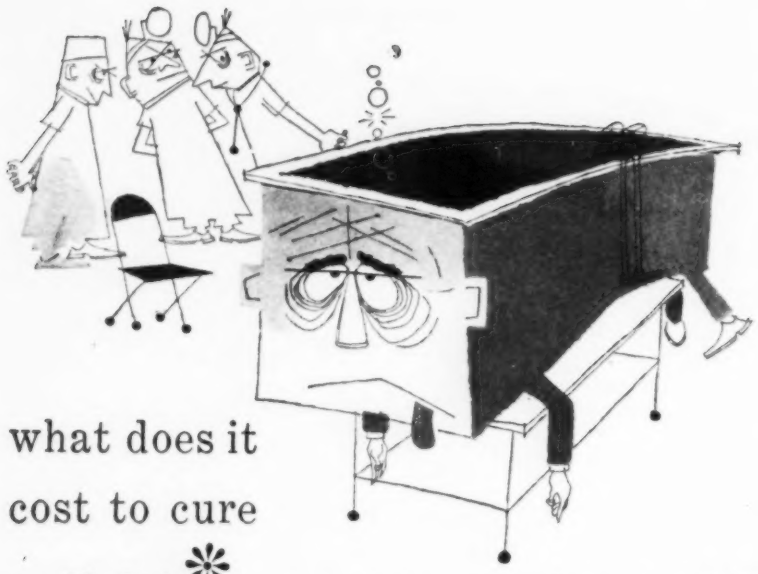
As near to you as your telephone

A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919


This is the art for next month's ads on the new Allmetal Plant in Garden City. Any Comments? C.W.
Maybe we should emphasize the product in the artwork - show various types of stainless steel screws, nuts, bolts, etc. C.T.
pretty picture, but a comparison is needed — show how new plant will increase production. Better "in stock" set-up. J.L.
mention somewhere that this new and larger plant makes possible faster service on special orders. J.M.
Don't let the newness of the plant obscure the old story, still true: Allmetal gives wide selection of standard and "AN" fasteners, quick delivery and fast production of "specials" too. Jc
use this
isfy. Write, on your letterhead, for our new, 96-page catalog No. 53
STAINLESS FASTENERS
ALLMETAL
SCREW PRODUCTS COMPANY, INC.
821 STEWART AVE., GARDEN CITY, L. I., N. Y.
TELEPHONE — GARDEN CITY 3-1200



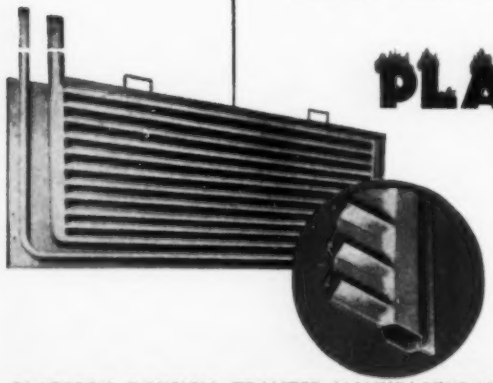
what does it
cost to cure
coil-itis* in your processing tank?

The constant care it takes to keep tanks operating when they're plagued with coil-itis is extremely costly. Downtime, and all the other maintenance time, slow heating and cooling ills of using old-fashioned pipe coils can be cured with Platecoils. As revolutionary as the new wonder drugs, Platecoils save as much as 50% in initial cost. They take 50% less space in the tank. They simplify maintenance and save hours of downtime. Compared to the hours it takes to clean and replace pipe coils, Platecoils can be cleaned and replaced in no time at all . . . without dumping the solution. It costs less to cure coil-itis with Platecoils than to suffer its evils. **Write for bulletin P77 today!**

PLATECOILS SAVE 50% IN HEAT TRANSFER COSTS

PLATECOILS COST LESS TO BUY, INSTALL, MAINTAIN

The Newcomb-Detroit Co., Grand Rapids Division, has found it is less costly to buy, install and maintain Platecoils than to fabricate pipe coils in their own plant. Ask about other case histories.



PLATECOIL

REPLACES PIPE COILS

*

Coil-itis — Diagnosed as tank heating and cooling problems. Platecoils — the prescription for solving pipe coil problems.

PLATECOIL DIVISION, TRANTER MANUFACTURING INC., LANSING 4, MICH.

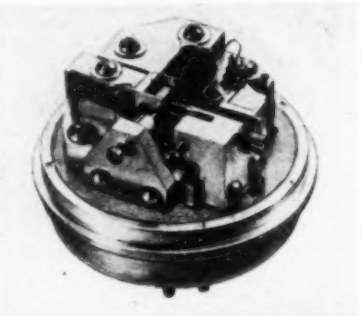
eliminates backlash. Maximum torque capacity (for size and weight), and long life because of changing contact points, are other advantages claimed for this type of clutch construction.

Formsprag Co.,
23601 *Hoover Road, Van Dyke, Mich.*

High-Frequency Impulse Relay

The type T high-frequency impulse relay, shown with the cover removed, was originally designed for use in an analog computer and for other applications which require a sensitive relay completely free from contact bounce and many operations at high speed.

This relay has a pull-in time of 120



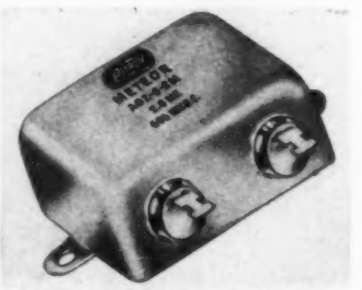
microseconds and a drop-out time of 100 microseconds, which enable it to follow 2,500 cycles per second; aperiodic to 1,000 cycles per second.

In a typical application it has a life expectancy, following a run-in period of 1×10^3 operations of 5×10^9 operations with a 0.75 ma contact load over a 6-month period without readjustment.

C. P. Clare & Co.,
4719 *West Sunnyside Ave., Chicago,* 30, *Ill.*

High Temperature Paper Capacitors

Meteor type ADZ, a new paper capacitor permitting operation to 125 C, without derating, is available in the JAN-C-25 bathtub case styles CP-53

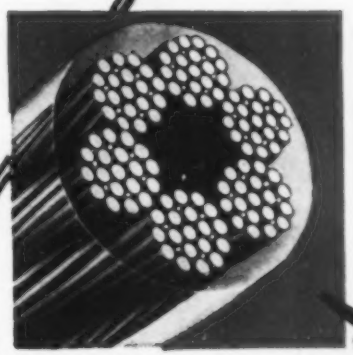


Write for

a sample of

WIRELON

the different kind of rope that does many jobs Better



Strong, tough, jewel-like Wirelon has proved to be the best kind of rope for many uses, ranging from heavy duty in industry to enhancement of consumer goods.

Perhaps it can do something better for you.

Do your **products or processes** require cable which resists fatigue and wear, is good looking, easy to handle, strong and long-lived? Do you have a **new problem** which Wirelon's stamina, safety and jewel-like handsomeness might solve?

It's wise to look into Wirelon. Write us on your letterhead and we will send you a sample piece of Wirelon, with specifications, so you can explore its possibilities.

Rochester Ropes, Inc.

ROUTE 15 CULPEPER, VIRGINIA

Rochester Wire Ropes—Used Wherever Quality is Important

WIRELON is a Rochester quality steel wire core completely encased in an extruded covering of tough nylon.

RESISTS FATIGUE. Gives up to 500 per cent longer service than uncoated cable.

WITHSTANDS ABRASION, kinking, fraying and other wear.

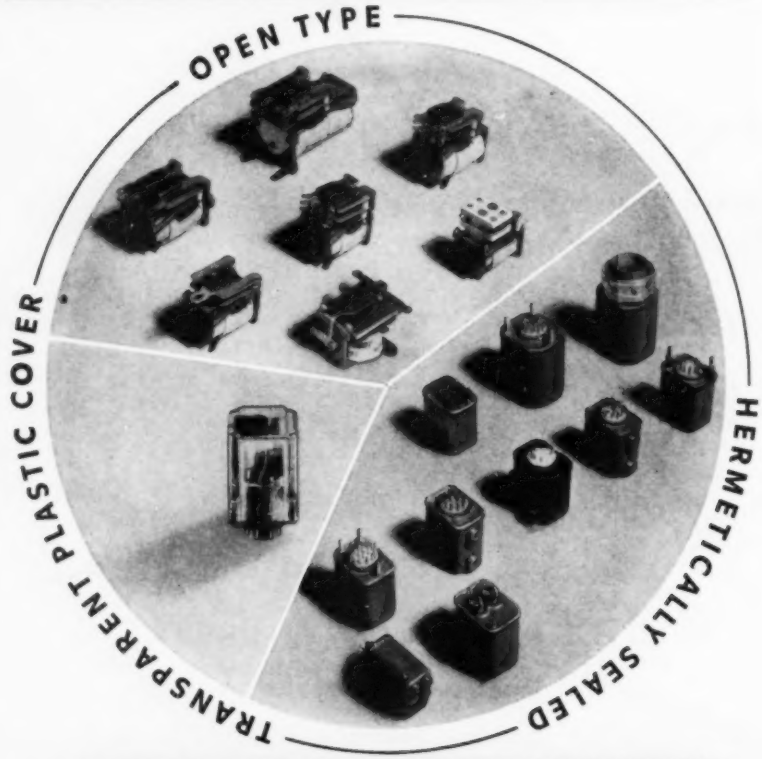
OPERATES reliably in extremes of temperature.

SAFE, smooth, easy to handle.

JEWEL-LIKE, strikingly handsome.

SIZES: 3/64 to 1⅛ inch diameter.

COLORS: natural nylon and many gem-like tones.



R-B-M Relays

FOR EVERY ELECTRONIC APPLICATION

Meeting Commercial and Government Requirements

OPEN TYPE. Circuit switching—power and dynamotor loads—plate circuit—low capacitance.

HERMETICALLY SEALED. Stud or bushing mounting—solder or plug-in headers—circuit switching—power—low loss applications.

TRANSPARENT PLASTIC COVER. Most R-B-M relays now available in low cost transparent plastic cover.

OTHER PRODUCTS: Motor starting relays and overload protectors for refrigeration, appliance and general purpose motors. Industrial contactors and across-the-line starters. NEMA size 1 and smaller. Low cost general purpose relays. Low voltage D.C. manual and magnetic devices.

Let R-B-M engineering and production facilities serve you. Contact us immediately—Phone 5121 Dept. C-9

RBM **R-B-M DIVISION ESSEX WIRE CORP.**
Logansport, Indiana

MANUAL AND MAGNETIC ELECTRIC CONTROLS FOR AUTOMOTIVE, INDUSTRIAL, COMMUNICATION AND ELECTRONIC USE

to CP-55. The new capacitors are furnished with glass-to-metal terminals to give a hermetic seal and dependable operation at high temperatures and altitudes.

Through the use of X-250, a new high temperature impregnant, made by this company, the type ADZ capacitor can be operated at temperatures from —65 C, to +125 C without derating.

To give good performance for low voltage, as well as high voltage applications, and to offer units with lowest possible resonance losses, the capacitors are supplied only in the extended foil, non-inductive type construction.

Multiple as well as single section capacitor construction is available in capacitors with terminals positioned in accordance with specifications.

Astron Corp.,
255 Grant Ave., E. Newark, N. J.

Cushioned Clamps For High Temperatures

Stainless steel, cushioned clamps that are flame-proof, fire-proof and able to resist temperatures as high as 1,200 F have particular application on aircraft jet engine installations, and for areas where flames and sparks are encountered.

The cushioning material is spun

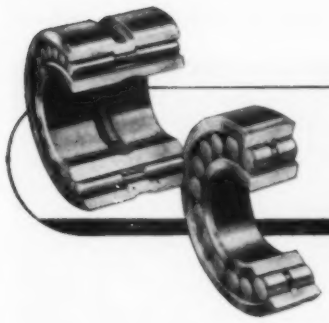
glass which is wrapped around the clamps. They are then dipped in a special aluminum and silicate base paint for a binder.

Designated the TA1716 and TA-1774 series, the clamps are available in sizes from $\frac{1}{8}$ to 6 in. dia, in increments of $\frac{1}{16}$ths in single and multiple tube clamps.

Thomas Associates, 4607 Alger St., Los Angeles 39, Calif.

Small Size, 14-Channel Oscillograph

Although this oscillograph measures only $7\frac{1}{4}$ in. wide by $6\frac{1}{4}$ in. high by $12\frac{3}{4}$ in. long, it is capable of



Over 33% Greater Capacity For The Same Size

There is a challenge facing manufacturers today to build smaller and more compact machines with extra precision and to combine more operations in each machine. This makes the selection of the proper bearings extremely important. A definite plus factor in this selection is the availability of a precision bearing that will deliver extra load carrying capacity in a minimum amount of space.

Obviously roller bearings, and particularly those of the small (needle) roller type occupy far less bearing space for equivalent capacity than ball bearings. Roller bearing capacity is built up in proportion to the effective race and roller contact provided. Thus a full type roller bearing *without space wasting cages* should provide the greatest capacity of any type of anti-friction bearing. However, to offer a perfect bearing the resulting full roller complement must be prevented from skewing and binding where misalignment occurs in the application.

The Guiderol bearing is the accepted answer to all these requirements considering precision, load capacity,

Bearing	McGill Guiderol No. GRI-209	Brand A Bearing	Brand B Bearing	Brand C Bearing	Brand D Bearing
Published Load Rating	8370 lbs.	6700 lbs.	7000 lbs.	5520 lbs.	6080 lbs.

Capacities at 2500 hours average life at 100 RPM

long life, versatility of mounting, and ease of lubrication. Published ratings show the Guiderol CT Series bearing has over 33% greater load carrying capacity than the average of the four highest rated interchangeable bearings. As a result, a Guiderol bearing at least one size smaller can often be substituted with the necessary shaft and housing requirements reduced in size and cost.

How Rollers Are Guided

In the Guiderol bearing design the grooved rollers with full race width contact are prevented from skewing by a center guide rail. Normally the rollers run on a true axis

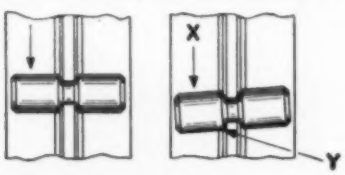
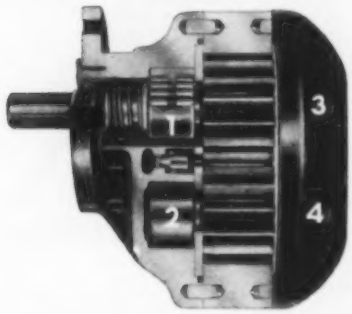


Fig. 1

Fig. 2

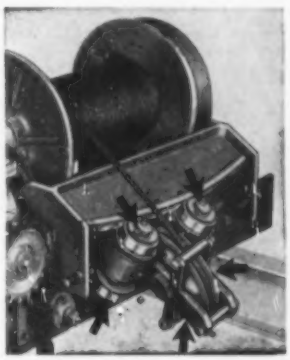
— not contacting the rail and thus need no correcting. (Fig. 1) Should misalignment cause a shift off center (Fig. 2) the leading end of the roller is retarded by contact with the rail at location Y. The trailing end catches up, relieving the rail contact, and the roller then resumes normal operation.

Typical GUIDEROL® Bearing Mountings

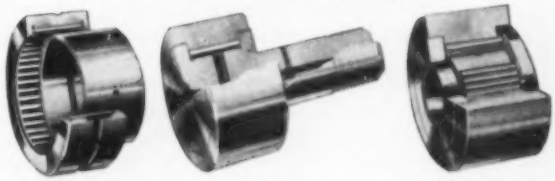


On a Hydreco Gear Pump Idler and Drive Shaft, 4 Guiderol bearings are used. The longer rollers of the Guiderol bearings are effective virtually to the edge of the races. This gives substantial support close to the gear and materially reduces shaft deflection.

Four Guiderol bearings support and guide an automatic spooling attachment across the face of the reel track on a 20,000 pound Gar Wood Reel-Rite Winch. The guided roller principle prevents skewing of rollers in the 4 vertically mounted bearings even with a 10,000 pound angular load per bearing. A fifth Guiderol bearing in the sheave provides added stability and eliminates binding due to off-center loading.



MULTIROL® Bearings



SE Series CF Series CYR Series

A new 140-page Bearing Reference Guide complete with 30 pages of vital engineering data has just been released by the McGill Manufacturing Company.

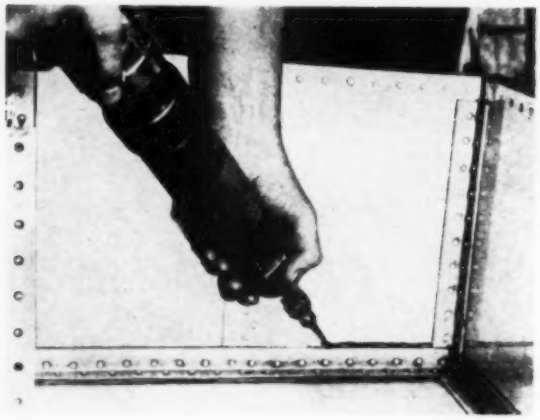
It has the full story on the advantages of Guiderol Bearings and in addition contains complete information on the well-known Multirol CF, CYR and SE Bearings. *Send now for your copy of the McGill Catalog No. 52.*

McGILL® — Precision Bearings

McGILL MANUFACTURING COMPANY, INC.
201 N. Lafayette Street, Valparaiso, Indiana

SPECIFY *Thiokol*® LIQUID POLYMER LP-2

for CRITICAL SEALING JOBS



Thiokol LIQUID POLYMER LP-2 IS A SOLVENTLESS LIQUID THAT CONVERTS TO A RUBBER AT ROOM TEMPERATURE WITHOUT SHRINKAGE.

Compounded and cured, "Thiokol" LP-2 has the following desirable combination of properties:

- TENACIOUS ADHESION TO GLASS, METALS, PLASTICS, WOOD AND LEATHER.
- INERTNESS TO OILS, MOST SOLVENTS, WATER, MILD ACIDS AND ALKALIES.
- IMPERMEABILITY TO GASES AND MOISTURE.
- INERTNESS TO OZONE, SUNLIGHT AND AGING.
- FLEXIBILITY AT EXTREME LOW TEMPERATURES.
- TOUGHNESS AND RESILIENCE.

Because of these properties, "Thiokol" LP-2 compounds are specified for sealing airplane wing tanks as pictured. It provides the required combination of properties and dependability in this critical application.

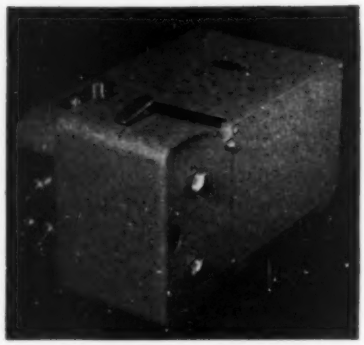
There are many other important sealing applications where "Thiokol" LP-2 provides the required combination of properties... sealing pressurized aircraft cabins and cold room windows... potting electrical connectors, transformers and wires... and bonding various combinations of metals, plastics, glass, wood and leather.

Perhaps "Thiokol" LIQUID POLYMER LP-2 can do an outstanding job for you. For technical information and samples contact:

Thiokol Chemical Corporation supplies "Thiokol" LP-2 only as a raw material. We will gladly indicate sources of supply to end-users.

Thiokol Chemical Corporation

784 NORTH CLINTON AVENUE, TRENTON 7, NEW JERSEY



recording 14 channels of separate data, with recording speeds of 1, 3, 6½, 13, and 32 in./sec. with the proper gear changes. Higher speeds up to 42 in./sec. are available as optional.

The timing lines are full-paper-width at 0.01 and/or 0.1 sec. (0.1 lines accentuated when 0.01 lines are used) by the use of a governor-controlled motor driving a shutter-type timer that is "g" proof. The magazine capacity is 100 ft., of 3⅝ in. wide recording paper. Power requirements are 24 v d-c at 9 amperes. A variety of precision galvanometers for use in this oscillograph have undamped natural frequencies up to 3,500 cps.

Midwestern Geophysical Laboratory, 3401 South Harvard, Tulsa, Okla.

Pressure Control Package Unit

The pressure control package unit shown is a preassembled combination of a diaphragm valve in a free flow pattern, together with a simple pressure control unit which can be dismantled, cleaned, and reassembled in less than two minutes. The sensitivity of the controller, plus the low pressure drop through the valve, is said to give a fine maximum flow condition. The type E296 package unit is available with 300 lb valve in standard or

for MICROSCOPIC precision

SPECIFY *Micro* BEARINGS

FULL RACE — *for most rugged duty in MICRO size range, increased load capacity.*

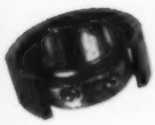
CONRAD RETAINER — *for low friction, high speed RADIAL and THRUST loads.*

SELF-ALIGNING — *for misalignment between shafts and housings up to 10 degrees.*

RIBBON RETAINER — *for smoother running, and lower friction.*

SPRING SEPARATOR — *for minimum starting or breakaway torque. Speeds — low to moderate.*

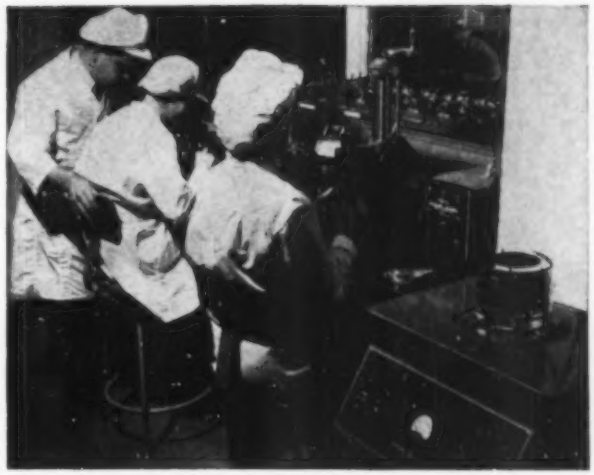
ANGULAR CONTACT — *for axial positioning of shafts with opposed pairs lightly preloaded.*



EXTRA-LIGHT CONRAD — *for minimum possible differences between shaft and housing dimensions.*

2¼ times Actual Size

PRECISION TO FIVE MILLIONTHS OF AN INCH IS READ ON THIS ELECTRONIC COMPARATOR



Hidden to the naked eye is the probable life of a precision bearing. This life depends on measurements by microscopic instruments and on microscopic cleanliness.

Common and accepted practice in some industries is to manufacture for 'LIMITED LIFE.' However, human lives often depend on **MICRO** bearings showing no signs of 'fatigue,' to which they are constantly exposed.

Our emphasis in manufacturing is for 'LONG LIFE' through microscopic accuracy including all accepted practices and inspection techniques.

MICRO is constantly developing new instruments for measuring minutely all dimensional and operating qualities.

Our inspections include surface finish and geometry of raceways and balls, running torque, and other features not yet covered by standards.

In all, 82 minute inspections guarantee 'LONG LIFE,' freedom from fatigue, for **MICRO** bearings.

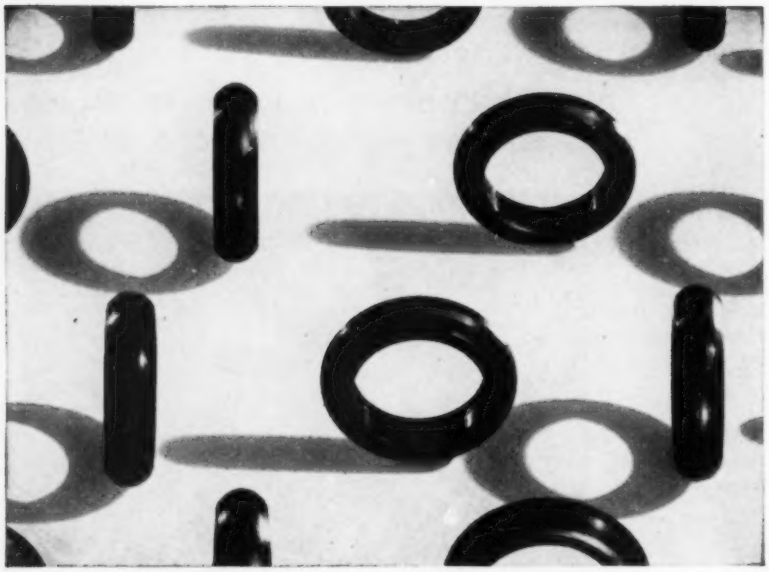
NEW HAMPSHIRE SPECIFY *Micro* BEARINGS **BALL BEARINGS, INC.**

54 MICRO CIRCLE • PETERBOROUGH, N. H. • TELEPHONE 424

Write for Catalog 53 for complete data on the more than 130 available **MICRO** bearings, or consult our Design Engineering Department.

SARAN RUBBER GASKETS ARE SOLVENT RESISTANT

Organic compounds like carbon disulphide, ethyl alcohol, trichloroethylene, xylene have little effect on saran rubber



Saran rubber mechanical goods exhibit outstanding resistance to a wide range of organic solvents from alcohols to xylol. They are characterized by a low degree of swell and a low rate of permeation to most solvents and gases. Carbon bisulfide, chlorine, phosphorous trichloride vapors with HCl, toluene, and trichloroethylene are typical compounds that are resisted by saran rubber gaskets.

Saran rubber is readily molded on conventional rubber molding equipment into complicated shapes such as diaphragms, valve pads, heavy-duty gaskets, and stoppers. These saran rubber products have been used in many and varied gas and solvent resistance problems confronting equipment manufacturers today.

Specify saran rubber to your molder. We will be glad to assist him in the development and production of saran rubber mechanical goods for your specific requirements. For a free data booklet on saran rubber molded goods write to the SARAN LINED PIPE COMPANY, 2415 Burdette Avenue, Ferndale, Michigan.

RELATED PRODUCTS

Saran rubber tank linings • Saran lined steel pipe—corrosion-resistant pipe that gives long-term operation with minimum maintenance costs.

Saran Lined Pipe Company
2415 Burdette Avenue, Ferndale, Mich.

Please send me your catalog on saran rubber molded parts.

Name_____

Title_____

Company_____

Address_____

City_____ State_____

53-1508

SARAN LINED PIPE COMPANY
2415 BURDETTE AVENUE, FERNDALE, MICHIGAN

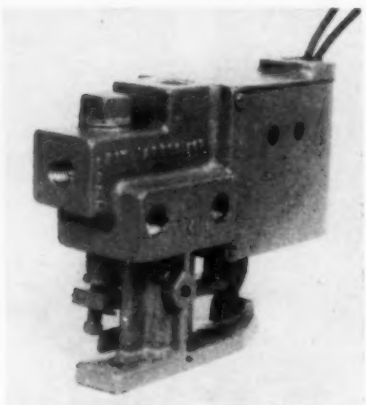
V-port assembly with a choice of pressure elements from 10 to 500 pounds.

Normal operation requires 30 lb. air pressure for the diaphragm, although some gases can be used directly through the control without an air supply.

Emmett Machine & Mfg., Inc.,
2249 14 *St. S. W., Akron* 14, *Ohio*

Solenoid Air Valve With Built-In Speed Controls

This new bantam ¼ in., 3 or 4-way solenoid-operated valve has adjustable speed controls which produce fast or slow movement of cylinder ram in either direction. The valve is fast operating and built for long wear, has stainless steel exhaust seats, brass seats,



brass inlet seats and phosphor bronze springs. It is furnished with either 110 volt or 220 volt constant duty solenoids, and will operate either a double or single acting cylinder.

Air Fixtures, Inc.,
Dept. 72; *North Manchester, Ind.*

Protective Finish For Magnesium

Iridite #15, a new protective finish for magnesium, is a chromate conversion coating that converts the surface of the treated part to a new, and chemically different surface. The film is resistant to atmospheric corrosion, as well as to corrosion from some chemical sources, the film is part of the metal itself, rather than a superimposed film, and will not chip, flake or peel when bent.

The film is produced by immersing the parts in the solution, which operates at room temperatures without electric current. No special equipment is needed. Immersion varies from

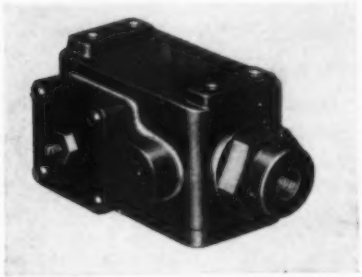
15 sec to 2 min., depending upon the condition of the metal prior to treatment.

The chemical is available in powder form, and one pound makes more than 3 gal of solution. It may be used on wrought, cast, or extruded magnesium, and may be used either as a final finish, or a base for paint.

Allied Research Products, Inc., 4004 East Monument St., Baltimore 5, Md.

Pressure Reducing Regulator Also Reduced In Size

Taking inlet pressures up to 2,000 psi, this small size pressure reducing regulator for air or oxygen systems, has adjustable output pressures from 50 to 300 psi, and handles flows up to 300 liters per minute. The manufacturers claim that the new regulator is



about one-half the weight and one-fourth the size of other regulators with this capacity, weighs 8 oz. and measures $1\frac{3}{8}$ x $1\frac{15}{16}$ x $2\frac{31}{32}$ inches.

Output pressure variation from zero to full flow is approximately 15 percent. The regulator will handle larger than 300 L.P.M. flow if the pressure drop from zero to full flow is allowed to drop more than 15 percent.

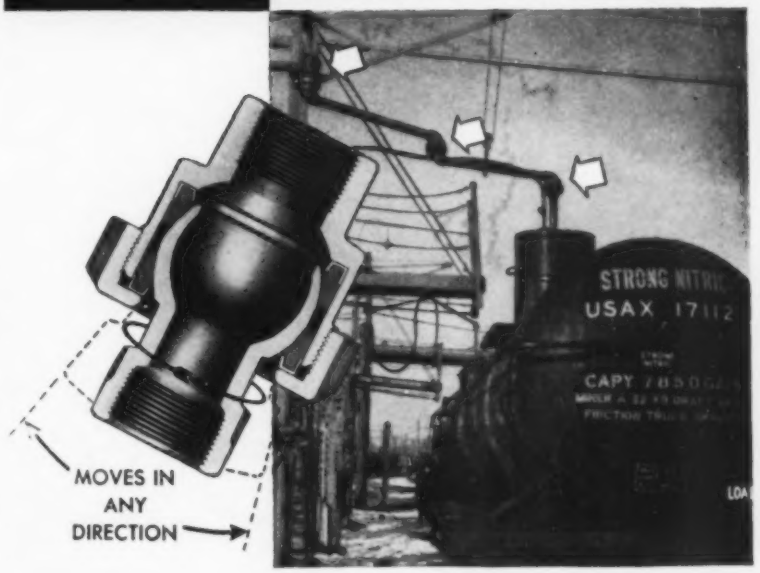
The Aro Equipment Corp., Bryan, Ohio

Precision Decade Inductance Units

A complete line of precision decade type inductance units, include the four ranges from 1.0 millihenry to 10.0 henrys and are available as single units which can be connected together to give an inductance range of as little as 1.0 millihenry to 10,000. The inductors are wound on toroidally shaped powdered molybdenum permalloy cores. Quality factors (Q) as high as 250 are obtainable with these units.

Torocoil Co., 1374 Mobile Ct., St. Louis 10, Mo.

BARCO *Flexible* BALL JOINTS



1. **MAXIMUM FLEXIBILITY.** Up to 40° side flexibility with 360° rotating movement.
2. **CHEMICALLY INERT GASKETS.** Barco offers a choice of seven types of gaskets including No. 11-CT for corrosive service. No lubrication required.
3. **NO METAL-TO-METAL CONTACT BETWEEN MOVING PARTS.** An important Barco advantage where corrosive chemicals are present, either externally or internally.
4. **STAINLESS STEEL BODIES.** Also regularly furnished in Malleable Iron, Steel, Bronze, Aluminum, and Magnesium. Other special alloy joints to order.
5. **MANY STYLES AVAILABLE.** Angle or straight; threaded or flanged connections. For pressures to 6,000 psi; temperatures to 1000°F. 15 different sizes, ¼" to 12".

—when you need movable joints in piping handling

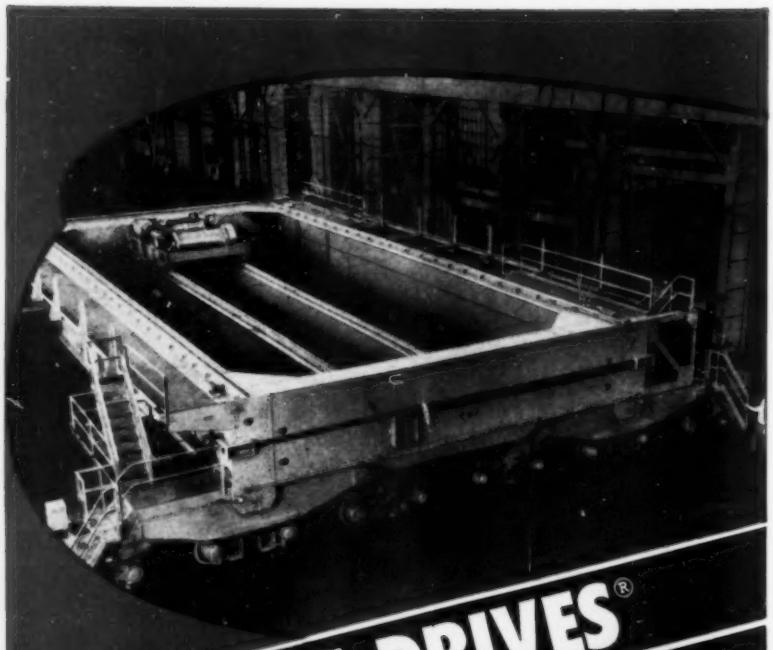
CHEMICALS

■ The above photograph shows BARCO BALL JOINTS used to provide flexibility in Nitric Acid Tank Car Loading Lines at the Joliet, Ill., Arsenal. This is but one of many installations in industrial plants where Barco joints are used to allow movement in piping conveying acids, alkalies, and solvents—as well as steam, air, oil, gas, or water.

BARCO BALL JOINTS offer many advantages over ordinary types of joints or flexible connections. When you want to be sure of getting SAFE, long-lasting, trouble-free installations, specify BARCO! Ask for your copy of Bulletin No. 215. *Worldwide Sales and Service.* BARCO MFG. CO., 527K Hough St., Barrington, Illinois. *In Canada:* The Holden Co., Ltd., Montreal.

BARCO

THE ONLY TRULY COMPLETE LINE OF FLEXIBLE BALL, SWIVEL, SWING AND REVOLVING JOINTS



Ten CONE-DRIVES® give compact power to steel mill crane

Morgan Engineering Company's 350-ton, 76-ft.-span ladle crane bridge features six individual 65-hp. motor drives that avoid line shaft designs.

Key to the success of this design incorporating parallel drives is the 12-in. center distance, 12/1 Cone-Drive gearset in each drive that cuts space requirements, resists shock loads and provides ample safety factor for smooth, rugged, long life operation.

Cone-Drive gearsets are also included in the drives for the 200-hp. main trolley hoists and auxiliary 20-ton and 60-ton hoists.

This is another example of the trend to Cone-Drive gearsets and standard speed reducers in steel mill equipment. Designers and users alike benefit from their long life and high capacity in less space at lower cost.

CONE-DRIVE GEARS

Division Michigan Tool Company

DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS

7171 E. McNichols Road • Detroit 12, Michigan

MEETINGS

September 3-17

ENGINEERING MARINE AND WELDING EXHIBITION—Olympia, London.

September 13-16

ELECTROCHEMICAL SOCIETY—Corrosion Symposium, Wrightsville Beach, N. C.

September 14-15

AMERICAN HOT DIP GALVANIZERS ASSOCIATION—Semi-Annual Meeting, Statler Hotel, Cleveland, Ohio.

September 14-17

SOCIETY OF AUTOMOTIVE ENGINEERS — National Tractor Meeting and Production Forum, Hotel Schroeder, Milwaukee, Wis.

September 14-17

INTERNATIONAL CONGRESS OF INDUSTRIAL DESIGN—Paris, France.

September 21-25

INSTRUMENT SOCIETY OF AMERICA —National Conference and Exhibit, Morrison and Sherman Hotels, Chicago, Ill.

September 28-30

NATIONAL ELECTRONICS CONFERENCE — Annual Conference, Hotel Sherman, Chicago, Ill.

September 29-October 1

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Middle Eastern District Meeting, Daniel Boone Hotel, Charleston, W. Va.

September 29-October 3

SOCIETY OF AUTOMOTIVE ENGINEERS—Aircraft Engineering Display and Aircraft Production Forum, Hotel Statler, Los Angeles, Calif.

October 7-9

NATIONAL ASSOCIATION OF CORROSION ENGINEERS — South Central Meeting, Mayo Hotel, Tulsa, Okla.

October 8-9

NATIONAL CONFERENCE ON INDUSTRIAL HYDRAULICS—Annual Meeting, Hotel Sheraton, Chicago, Ill.

October 8-9

SOCIETY OF THE PLASTICS INDUSTRY—New England Section Meeting, Equinox House, Manchester, Vt.

Sans, Souci

Ad Libbing by the Editor

Fortunes have been spent in trying to train all people to do certain things in exactly the same way. Men and women have spent almost their whole lives in the study of habits and training methods. As our so-called civilization became more complex the need for mass training of humans increased.

Keeping to the right, lining up for tickets, operating a slot machine, running an automobile and thousands of other human operations and activities have been rigidly standardized. Failure to observe some of the do's and don'ts may result in the infringer being put in jail. The person who ignores the red light and thereby imperils others must be chastised properly. Man cannot exist in this complicated world without certain restrictions and compulsions.

As Mark Twain emphasized, there are many good things in life but they are no longer good if carried to excess. Most of the world's troubles are created by excesses. Mark Twain pointed out that one should eat, drink, love, sing and do many other things, but not to excess. To his list we can add, "Standardize but not to excess."

There are many kinds of standardization. Some are good, some are not so good. Standardization for interchangeability of parts is unquestionably good. But when it comes to standardization of human behavior and tastes, its virtues may be questionable or even nonexistent.

Perhaps the greatest "operation standardization" is the "back seat driver". Two human entities are involved. One is the "standardizer", the other is the victim. The "standardizer" just cannot understand why the "victim" does not do what the "standardizer" thinks he or she would do if he or she were driving the car.

Now there would be no trouble with standardization fanatics, and all others of the same school of thought, if all of us humans behaved like a low form of life such as beetles, birds, sheep or fish. Every beetle behaves in exactly the same manner every time it is subjected to a given stimulus or condition. That is also true of every other low form of life. The first indication of

Continuous baking with trouble-free CONE-DRIVE® power

Petersen Oven Company's Ec-Tri-Flex 73" production bakery oven is an example of modern food processing equipment designed for maintenance-free, continuous operation.

A conveyor moves bakery products through the oven continuously on 21 stabilized transite trays. If the conveyor stops, food can be ruined. Shutdowns for conveyor drive repairs can ruin the best production schedule.

Petersen engineers insured against this danger by using a **standard** 3" center distance 40/1 Cone-Drive speed reducer in the conveyor drive system. And, this reducer has given trouble-free service in over 30 installations.

Standard Cone-Drive speed reducers and gearsets are providing similar 'service reports' throughout the food industry. As off-the-shelf replacement units, they can modernize your present equipment.

CONE-DRIVE GEARS
Division Michigan Tool Company
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
7171 E. McNichols Road • Detroit 12, Michigan

MARSH impregnated leather Packing Leads Again!

MARSH BEST SINCE 1900 LEATHER PACKINGS

New MARSH development will increase the life, efficiency and prestige of your product!

Our research division—pioneers in the development and improvement of impregnated mechanical leathers—offers you a new, tougher—wear, age and extreme temperature resistant—impregnated mechanical leather packing, possessing remarkable resilience and flexibility.

ENGINEERING AND CONSULTING SERVICE

If you seal oil, water, air, vacuum, gas, gasoline, naphtha, alcohol or other fluids, ask Marsh for field engineering service.

FEATURES: Low coefficient of friction—both static and running, greater wear resistance, tighter sealing, better high and low temperature stability, improved lubrication potentials, longer life.

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Sans, Souci .....**continued**

intelligence is the ability to make a decision and take an action that is not compelled by instinct or dictated by an external influence or command. Dogs and horses show such signs of intelligence.

For a person to have his behavior subjected to standardization tends to stultify the individual. Brilliant minds suffer agonies when they are forced to draw their conclusions and conduct themselves by rule and rote instead of reasoning.

Creative thinking cannot be standardized. There can be no thinking in a standardized mental process such as found in low forms of life. Such a mental process is not "thinking" it is merely instinct. Man's great accomplishments in the arts and sciences were the result of creative thinking, not instinct.

Dr. Charles F. Kettering tells the story of the development of the General Motors diesel engine for railroad service. The "heart" of the engine was the fuel injection pump. Several years of development work failed to produce the desired result. Finally Dr. Kettering gave the job to a young engineer who knew nothing about fuel injection pumps and told him "I want you to keep your mind clear of other peoples' ideas on the problem. Here are the conditions under which the pump must operate.

"Now you can do what you please, go where you please, have any experimental apparatus or models made as you desire. You will report to no one until one year from today. I want you then to come into this office and report to me. Of course if you want to see me sooner, I will be glad to see you."

In about six months or so, the man came in to "Boss" Kettering and placed on his desk a model of the desired pump. As Dr. Kettering explained it, the man did not have his thinking circumscribed by a lot of directives, needless restrictions, and similar "back seat driving" advice. The only advice given him was to keep his mind free of other peoples' ideas of what the pump should be like.

Much is to be gained in keeping the atmosphere of the engineering department as free as possible of "standardized procedures". Some are necessary. But none should be permitted that will channel thinking into time worn grooves. Standardization carried to excess can spell stagnation.

Catalogs and Bulletins

Request additional information using postcards following page 236

(1) ENVIRONMENTAL TEST EQUIPMENT—American Research Corp. Booklet, 4 pp. Illustrates and gives complete data on a line of environmental testing gear for testing under conditions of: altitude, temperature, humidity, rain, sunshine, sand, and dust. Temperatures as low as —175 F, and as high as 200 F.

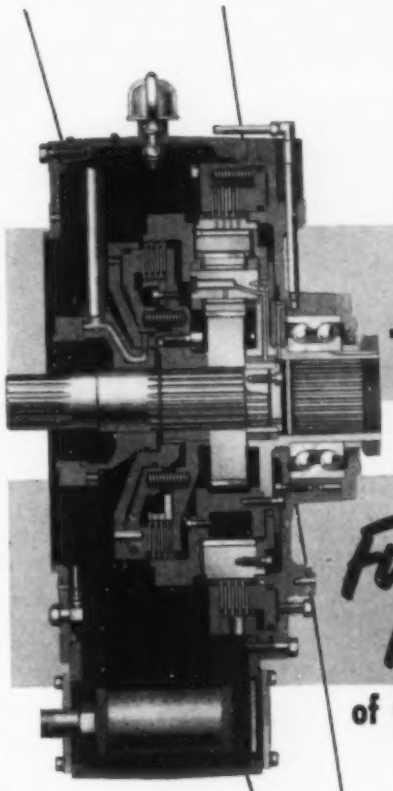
(2) TERMINAL BLOCKS—Kulka Electric Mfg. Co., Inc., Catalog 14, 20 pp. Describes a line of terminal blocks, special Navy terminal blocks, and aircraft and electronic switches. Illustrations are shown for each block with various types of terminals.

(3) ALLOY SPRING STEELS—The International Nickel Co., Inc., Booklet, 18 pp. With charts, tables, and photo-micrographs, it compares the mechanical properties of three alloy steels: nickel-chromium-molybdenum, silico-manganese, with plain carbon spring steel. Gives experimental procedure and results.

(4) CASTING IMPREGNATION—American Metaseal Mfg. Corp., Booklet MMC-048, 8 pp. Contains developmental and application story of the impregnation of porous castings. Illustrations show how the impregnation by a solid copolymer differs from older methods. Tables included to give the properties of the impregnant.

(5) CASTING RESINS—R. S. Aries & Associates, Booklet, 8 pp. Has complete engineering specifications on potting and casting resins for electrical work. Gives nature of the resins, the various properties, and applications.

(6) METAL STAMPINGS—The Quadriga Mfg. Co., Booklet 865, 16



NEW

2-SPEED TRANSMISSION extends Full-Range Performance of your Torque Converters

Engineered specifically for use behind three-stage torque converters, the new Twin Disc 2-Speed Transmission—Model T-302—permits converters to deliver extended performance within their *maximum* operating range.

New Model T-302 is completely *oil-actuated*, for smoother, more positive action—designed around a planetary system with lock-up feature for *direct drive*. Installed on your 3-stage torque converter, it provides three operating positions: Neutral, Low, and High. Ratio spread is available in 2.69:1 or 3.07:1. Entire unit is self-lubricated.

To gain the advantages of extended performance from 3-stage torque converters on *your* equipment, get this newest development in transmissions. For full details on the new Model T-302 2-Speed Transmission, contact your nearest Twin Disc Factory Branch or Twin Disc Clutch Company, Hydraulic Division, Rockford, Illinois.

New Twin Disc 2-Speed Transmission, Model T-302, designed to give 3-stage torque converters extended performance within maximum operating range. Engineered for easy installation.

Built for a Long Life . . . Backed for a Lifetime

TWIN DISC CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

BRANCHES: CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEWARK • NEW ORLEANS • SEATTLE • TULSA

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- HEAT RESISTANCE
- ARC RESISTANCE
- STRENGTH & WEAR RESISTANCE
- STABILITY

in molded electrical parts?

Today's new Ace Hard Rubber compounds are far more than "just good insulators" in electrical-mechanical parts. Look at these representative values: Tensile strength to 10,000 psi, moisture absorption as low as 0.04%, power factor 0.006; arc resistance as high as 190; dielectric strength to 600 v/mil; surface resistance over 10^8 megohms; heat resistance to 300 deg. F. Compounds can be blended to give just the right combination of properties for each job...economically, too, because it's never necessary to "over-design." Practically any size and shape can be molded, even with complicated inserts. Machinable to close tolerances, with excellent dimensional stability. Why not check up on today's new compounds for your designs?

ACE® dielectrics:

High dielectric sheet and extruded shapes ideal for myriads of punched or machined parts.

Design hints covering wide variety of Ace hard rubber, Ace plastics, and rubber-plastic blends are available in 80-pg. Ace Handbook. Write for your copy today.

ACE rubber and plastic products

AMERICAN HARD RUBBER COMPANY
93 WORTH STREET • NEW YORK 13, N. Y.

pp. Has many illustrations and tables giving data on tension washers, friction washers, wire terminals and finishing washers. Illustrations of a wide variety of stampings possible. Gives lists and sizes of progressive and compound washer dies available.

(7) PRECISION BUILT DRIVES—Central Die Casting & Mfg. Co., Booklet, 8 pp. Specifications and illustrations for a line of: V-grooved pulleys for A-$\frac{1}{2}$ in. belts, and B-$\frac{5}{8}$ in. belts; variable pitch pulleys; flexible couplings; bronze bearing mandrels; bronze bearing pillow blocks; round belt pulleys; V step cone pulleys; crown faced pulleys; and crown face-V-grooved combination pulleys.

(8) ELECTRONIC COMPONENTS—American Phenolic Corp., Catalog B-2, 50 pp. Lists and illustrates a complete line of cables, plugs, connectors, fittings, sockets and plastic components. Has complete engineering data, cross-sectional views and other informative data.

(9) FURNACES FOR TENSILE TESTS—Labquip Corp., Booklet, 4 pp. Information on tubular furnaces used for tensile tests, and the control panels, used with the furnace. Temperatures up to 2,000 F and higher with special heating element.

(10) AIR & HYDRAULIC COMPONENTS—Rivett Lathe & Grinder, Inc., Booklet 15 M, 4 pp. Describes the application of air and hydraulic power, illustrating a condensation of a line of: air and hydraulic cylinders; air valves; and hydraulic valves. Also has an enlarged cross-sectional drawing of a representative of the above components.

(11) FLEXIBLE SHAFTING—Stow Mfg. Co., Design Manual 528, 16 pp. Charts for the selection of the correct size flexible shaft are shown for valves up to 27 in. dia. handwheels. Different types of end connections, and intermediate connections are shown in detail. A drawing shows a typical arrangement of flexible shafting for remote valve operation.

(12) MAGNETS—The Ohio Electric Mfg. Co., Bulletin 112, 8 pp. Illustrated with cutaway sections, photos, and application photos of lifting, sep-

New facts for your file on

USS HIGH STRENGTH STEELS — UNITED STATES STEEL — TWENTY YEARS OF PERFORMANCE

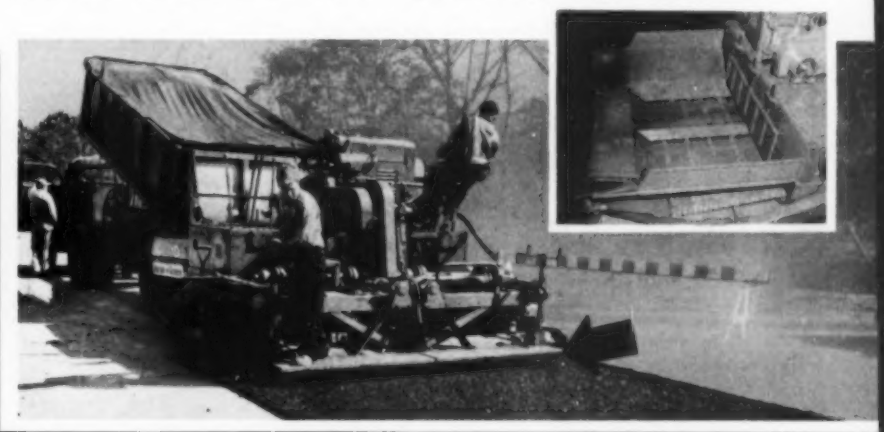
U·S·S HIGH STRENGTH STEELS

U·S·S MAN-TEN steel ensures long life of vital parts by providing strength plus high resistance to wear

● Distinguished for its performance as a road paver, the Barber-Greene Finisher tamps, levels and strikes off simultaneously—provides an unusually efficient method for laying a compact, level course of bituminous mix.

Made of ⅜" MAN-TEN steel, accurately ground to flatness and highly polished, the screed plate (arrow), which rides on the laid pavement and gives it a smooth, ripple-free surface, is one of the most important components of this unit. Says the manufacturer, "Much of the success of the paving operation and the ultimate quality of the road surface reflect the quality of the material and manufacture which goes into the screed plate. That's why we use U·S·S MAN-TEN steel."

The bed of the receiving hopper is also made of U·S·S MAN-TEN steel, ¼" thick. After the load of hot mix is dumped into this hopper, chain-mounted flights draw it across the bed plates. Abrasive action is severe and the bed plates take a beating so it is imperative that they be made of especially sturdy and long-wearing material. Again MAN-TEN steel fills the bill. Its relatively low cost and easy fabricating qualities further recommend MAN-TEN steel for applications of this kind, where strength and durability are of prime importance.



By saving weight in portable masts, U·S·S MAN-TEN steel cuts costs and saves time for the oil driller

Every pound saved is of vital importance to the users of this equipment. For every time a drilling derrick or portable mast is moved, the less it weighs, the less it costs to dismantle and ship to a new location.

With masts built 25% lighter with U·S·S MAN-TEN steel, trucking costs are substantially reduced. In moving a mast from Texas to Montana, for instance, the driller might easily save two thousand dollars or more.

But lighter MAN-TEN steel construction ensures even more important savings in the greater speed with which a mast can be lowered, placed on a truck, hauled to the next site and re-erected. Here, weight saving means time saving, which means more wells drilled—more money in the driller's pocket.

That's why Lee C. Moore Corporation cantilever masts and derricks have been built lighter with U·S·S MAN-TEN ever since this high strength steel was first introduced twenty years ago. Used in the legs and principal structural members, in angle sizes ranging from 4" x 4" x ⅜" to 8" x 8" x 1⅛", MAN-TEN steel replaces carbon steel of almost 25% greater thicknesses. Because MAN-TEN steel has a 50% higher yield point, this lighter construction is also stronger and, thus, has a greater pulling capacity. For example, a 136' high standard derrick with a 30' base constructed of 8" x 8" x ⅝" and 8" x 8" x ½" carbon steel leg members, weighs 42,000 pounds and has a pulling capacity of 465,000 pounds. On the other hand, a similar sized standard derrick built of MAN-TEN steel also weighs 42,000 pounds but has a pulling capacity of 645,000 pounds. In addition, MAN-TEN steel's 40% higher fatigue strength materially prolongs life by providing added durability.

USS

UNITED STATES STEEL CORPORATION, PITTSBURGH · AMERICAN STEEL & WIRE DIVISION, CLEVELAND · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
NATIONAL TUBE DIVISION, PITTSBURGH · TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

New facts for your file on U·S·S CARILLOY STEELS

Every B-36 lands on U·S·S Carilloy steel

● When 179 tons of B-36 thump down on a landing strip, tremendous stresses are built up in the structural parts of the landing gear. Only the highest quality in steel can handle this tough job, which is one of the most exacting in the aircraft industry.

All of the rugged main columns for these landing gears are made from U·S·S CARILLOY electric-furnace aircraft quality ingots. This high quality alloy steel provides the great strength and shock resistance demanded in the performance of the finished part. The main columns for these landing gears are forged. The original ingot, as shipped to the forger, weighs approximately 37,500 lbs. From it are produced two columns, each weighing about 1200 lbs. In other words, approximately 93% of the steel has been removed—with a mere 7% of the original ingot left to do this tremendous job. Obviously, this steel must be of the very best quality.

The same care and skill go into every ton of CARILLOY steel that *you* buy, whether it's a giant alloy ingot or a few tons of special steel. Our experienced metallurgists keep a close check on *every* heat of steel to make sure it has the strength, hardness, toughness and machinability that's needed.

If you have a special steel problem, let us know. We'll be glad to help you with it.

No ordinary steel could withstand the huge shock loads imposed on the main landing gears of Convair's giant Air Force B-36 Bomber. The plane has a maximum gross weight of 358,000 lbs., with still higher landing shock loads. But U·S·S Carilloy steel has more than enough impact strength to hold up under this severe punishment.

U·S·S Carilloy electric-furnace aircraft quality steel meets every requirement for these vital parts. The precision machining and expert heat treatment they get at Cleveland Pneumatic Tool Company complete the job.

USS

UNITED STATES STEEL CORPORATION, PITTSBURGH · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO

TENNESSEE COAL, IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST

UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

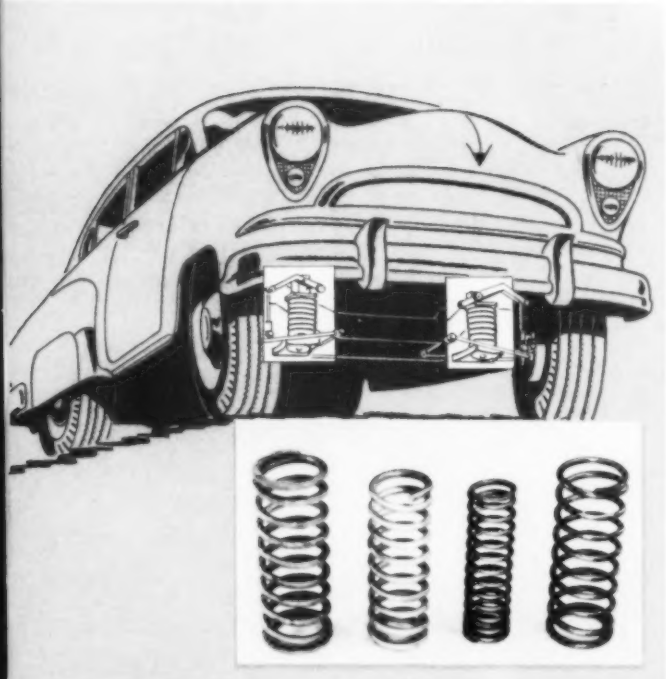
New facts for your file on U·S·S CARILLOY STEELS

HALF THE NEW CARS HAVE COIL SPRINGS MADE OF U·S·S CARILLOY PRECISION ROLLED COIL SPRING ROUNDS . . .

• they are twice as accurate as ordinary hot-rolled bars

• require little or no centerless grinding

• and they cost less to use



● In the early days of the development of coil springs for front suspensions of automobiles, the only steel that was available was an ordinary hot-rolled bar from which as much as .035" of metal per side had to be removed by grinding to insure freedom from harmful seams, pits, and decarburization. This cost money, was wasteful and time consuming.

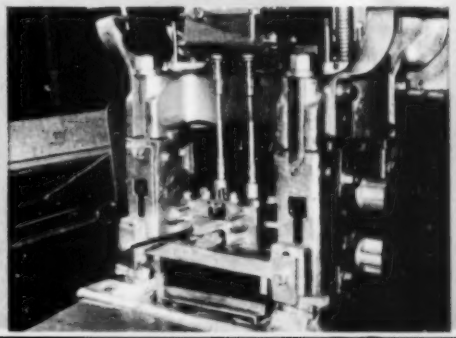
This seemed to be an expensive approach to a simple problem, so United States Steel equipped one of their mills to produce hot-rolled bars to eliminate harmful defects and most of the grinding expense. They devised a method for rolling a bar to half the standard tolerances, with half the amount or less of decarburization, which made it attractive to use the material "as furnished" or with a small amount of centerless grinding. We call this bar a Precision Rolled Coil Spring Round. It has performed excellently when used "as furnished" or with a small amount of grinding.

This exclusive development has paid off in two ways. It paid us because the CARILLOY Precision Rolled Coil Spring Round is now used in over half of the coil springs in new automobiles. But, most of all, it has paid off for the automobile manufacturer in that his costs are reduced with performance of the highest order. Today we are still hard at work developing new and better alloy steels for other new uses in automobiles; for example, in automatic transmissions, power steering units and other new and vital automobile parts.

Our experienced engineers and metallurgists will be glad to consult with *you* on any steel or fabrication problem. Just write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

Here, at Muehlhausen Spring Division of Standard Steel Spring Co., precision rolled U·S·S CARILLOY Coil Spring Rounds are coiled without centerless grinding. CARILLOY Rounds have a guaranteed minimum decarburization, and they cost less to use.

At the Gary Works of United States Steel, this precision mill rolls CARILLOY Coil Spring Rounds with extreme accuracy. Tolerances are only half of standard; .004" on the diameter, instead of the usual .008", and only .008" out of round, compared to .012" on ordinary rolled bars.



Coil springs made of CARILLOY Precision Spring Rounds have been proved in severe laboratory tests, as well as in actual service on America's best automobiles. They perform so well that half of all automobile coil springs are now made of CARILLOY steel.

USS

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UNITED STATES STEEL

New facts for your file on

U·S·S STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

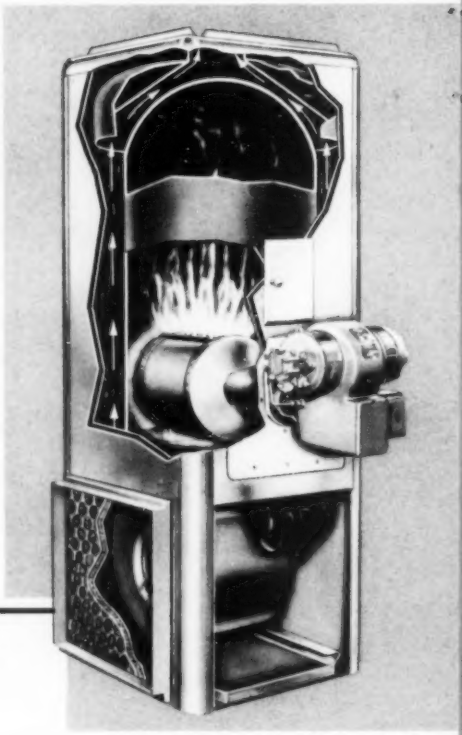
Type 442 Stainless Steel performs well in firebox of oil-fired domestic furnace

● A prominent manufacturer is currently using U·S·S 21 (Type 442) Stainless Steel for the firebox assembly of its oil-fired domestic furnace.

This oil-fired unit has a chamber, approximately 10 inches long and 12 inches in diameter, composed of a cylinder with an open top to which is spot welded a front cone and a rear cone. Operating temperature is 1600° to 1800°F.

When restrictions prevented the use of a nickel-bearing grade, this manufacturer turned to Type 442, a straight-chromium grade of Stainless Steel. Type 442 has performed satisfactorily from the fabricating standpoint. There has been no trouble in drawing and forming, and its oxidation resistance is considered equal or superior to the nickel-bearing grade previously used.

Stainless Steel sheets used are 20 gage.



CROSS-SECTIONAL VIEW of an oil-fired furnace with its firebox of Type 442 Stainless Steel.

20-quart dishpans deep drawn from Type 430 Stainless Steel

THIS 20-QUART dishpan shows the excellent drawing characteristics of Type 430 Stainless Steel. It was made by Peal Manufacturing Company, Cincinnati, Ohio.

● Twenty-five thousand of these 20-quart dishpans have been manufactured for the Army Quartermaster Corps by Peal Manufacturing Company, Cincinnati, Ohio, using Type 430 Stainless Steel.

The 19-gage sheets are ordered to $26\frac{3}{4}''$ x $80\frac{1}{4}''$, and are first sheared into a square and then into a circle. Two tapered-side draws form the pan, the end flange is folded in, the surface is ground, and handles of Type 430 Stainless Steel are welded to the pan.

Type 430 Stainless Steel has presented no problems in fabrication in this application.

HELPFUL SUGGESTIONS ON FABRICATION

Our book, "Fabrication of U·S·S Stainless and Heat-Resisting Steels," contains information that will be helpful to you, no matter what grade of Stainless Steel you are using. If you would like a copy, send your request to United States Steel Corporation, Room 2816-I, 525 William Penn Place, Pittsburgh 30, Pa.

USS

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UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

aration, and road-sweeping magnets. Also gives magnet weights, and lifting capacities for all standard bolted, welded, and basket type magnets.

(13) TITANIUM ALLOYS—Mallory-Sharon Titanium Corp., Booklet, 16 pp. Has information on different production methods, general properties of various alloys, standard production classifications and testing procedures, and the specific qualities of 5 types of titanium and its alloys.

(14) PRINCIPLES OF HEAT TREATMENT—Meehanite Metal Corp., Bulletin 40, 43 pp. Explains annealing, hardening, martempering, austempering and surface hardening in detail through the use of charts and photographs. Equilibrium diagrams, dilatation curves, S curves, and Jominy curves and explanations are included.

(15) LEATHER & SYNTHETIC RUBBER PACKINGS—Graton & Knight Co., Catalog 201, 60 pp. Discusses the types of mechanical packings and application of cup, flange, U, and V packings. Under leather packings it discusses dimensional data of the above types plus crimps, water-well cups, valve leathers, and special packings. Under synthetic rubber packings it gives general properties and characteristics on the above mentioned types. Has many illustrations, cross-sectional views, and charts.

(16) SELENIUM RECTIFIERS—Vickers Electric Div., Bulletin 3000, 8 pp. Describes the selenium cell construction, design factors, and covers the single and three-phase circuits and characteristics; ratings; performance curves; and construction data. Has many illustrations and engineering data.

(17) ELECTROLIZING—The Electrolizing Corp., Booklet, 14 pp. Defines electrolizing, and aids in serving as a guide in helping to solve wear, abrasion and corrosion problems. Has a question and answer section on electrolizing, gives case histories showing how wear of parts has been reduced.

(18) LUBRICANTS—The Alpha Corp., Bulletin 100, 8 pp. Describes a new principle in lubrication having a concentrated and purified molyb-

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denum as the basic ingredient. Gives complete details on the regular line, plus information on a new type having a temperature range of —40 F to 400 F; and a new grease consistency mixture.

(19) INSTRUMENT MOTORS—Servomechanisms, Inc., Catalog, 20 pp. Describes a new line of miniaturized hysteresis synchronous, control, and damped control instrument motors. Typical uses include: analog computers; differential analyzers; telemetering devices; and others. Has illustrations, specifications and performance curves.

(20) HOSE FASTENER—Eaton Mfg. Co., Engineering Folder 1, 4 pp. Lists advantages of a new hose fastener made in one piece that is reusable and which can be applied with a pair of pliers. Used on machine tools, air lines, automobile engines, and welding equipment. Chart gives sizes, material and other data.

(21) SUB-MINIATURE INDICATOR LIGHTS—Dialight Corp., Booklet L-153, 4 pp. Has complete specifications for a line of indicator lights made to mount in a $\frac{1}{32}$ in. clearance hole, and equipped with any midget flanged base T-$1\frac{3}{4}$ bulb. Has illustrations of all types.

(22) STEEL CASTINGS DATA—Steel Founders' Society of America, Booklet, 16 pp. Titled, "Carbon and Low Alloy Steel Castings," it has data covering steel casting properties, specifications, design, joining, heat treating, and inspection procedures. Has a two-page chart devoted to general engineering types of steel castings classified according to tensile strengths.

(23) WIRES & CABLES—U. S. Wire & Cable Corp., Catalog PM-3, 24 pp. Lists and illustrates wires and cables used in such industries as communications, electronics, aviation, transportation, appliances, automotive, television, building, and others. Has reference tables, diagrams, charts and each class of wire or cable is described in detail as to construction, chemical and physical properties and typical uses.

(24) HERMETICALLY SEALED RELAYS—General Electric Co., Bulletin GEA-5729 A, 4 pp. Describes

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in the Drive Line Assembly with INTEGRAL SAFETY SHIELDS!

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An exclusive Blood Brothers feature, these Integral Safety Shields have won wide approval in the field for years. Today they are used on mowing machines, corn pickers, forage harvesters, hammer mills and other implements. You can specify them on assemblies from the K-1-C Series on through 35N Series sizes . . . on non-slip front or two-joint slip assemblies.

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a line of hermetically sealed relays for electronic applications. They meet provisions of MIL-R-6106 military specifications, and performance requirements of MIL-R-5757 B. Has application, performance, and features of relays, plus specification charts, and dimensional diagrams.

(25) MECHANICAL PRESSURE GAGE—W. C. Dillon & Co., Inc., Bulletin PG-2, 5 pp. Has all engineering data on a compact instrument designed to measure mechanical pressures or compressive loads in a limited space, to pressures of 5,500 pounds. Has many illustrations showing variety of applications. Largest overall length by width is $4\frac{3}{4}$ x $3\frac{1}{8}$ inches.

(26) MOLDED PRODUCTS—Molded Products Corp., Booklet, 16 pp. Has information on facilities and examples of type of product, and adaptability to: laminating reinforced materials; thermoplastic molding; rubber pad molding; rubber molding; metal forming; metal brazing. Has many illustrations.

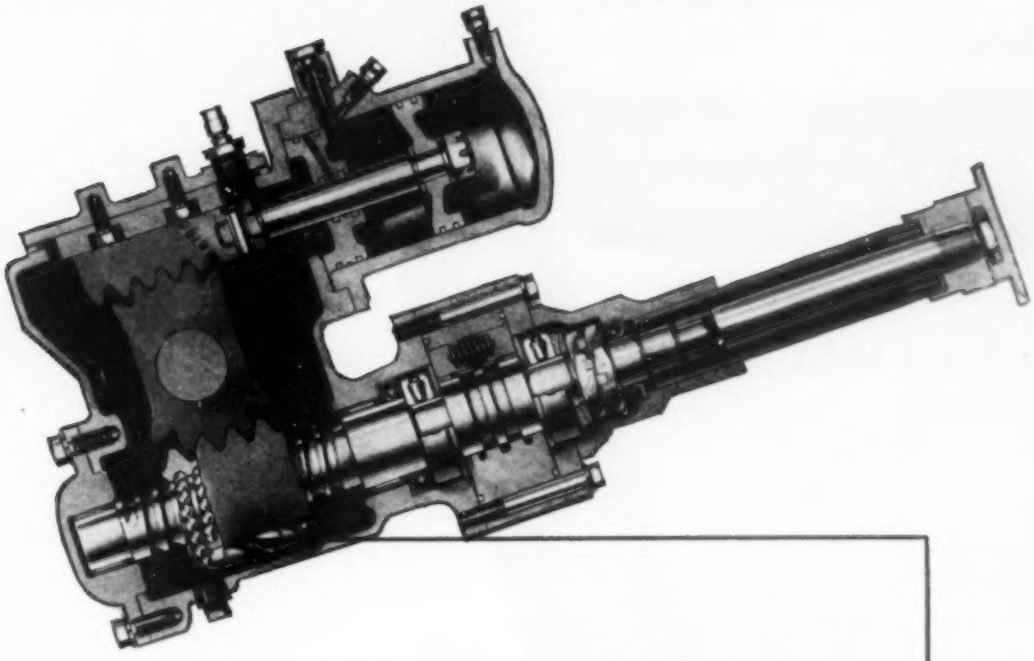
(27) STAINLESS STEEL PARTS—G. O. Carlson, Inc. Bulletin, 4 pp. Lists and illustrates a complete line of stainless steel plates, forgings, sheets (No. 1 finish), tank heads and flanges. Stainless steel rings and disks are shown as typical of the various forms available.

(28) ALUMINUM EXTRUSIONS—Revere Copper & Brass, Inc., Booklet, 28 pp. Diagrams are used along with tables in presenting the standard tolerances of aluminum extruded shapes. Included with typical examples are the tolerances in detail for straightness, twist, corner and fillet, radii, length angularity, contour of curved surfaces, flatness, and cross sectional dimensions.

(29) LACQUER EMULSIONS—Hercules Powder Co., Booklet, 8 pp. New developments in emulsifying agents techniques and uses are described, including data on film-formers, resins and plasticizers, solvents and diluents, emulsifiers, coloration, emulsifying equipment, and emulsion stability.

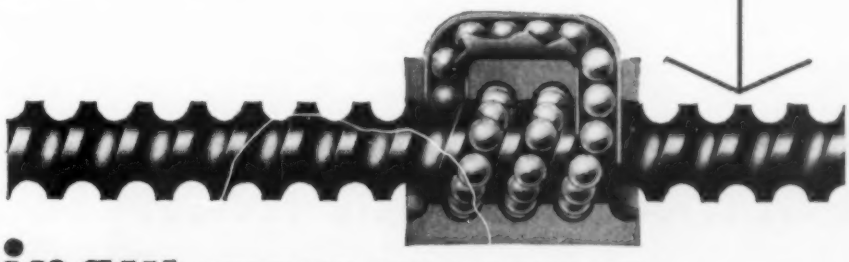
(30) AIR-TURBINE DRIVES—Fairchild Engine & Airplane Corp., Book-

SAGINAW BALL BEARING SCREWS + HYDRAULIC "MUSCLE" = SAGINAW POWER STEERING



Saginaw Power Steering, which is already the most popular power steering unit in the country, still employs the highly efficient Saginaw Ball Bearing Screw. The principal difference is that hydraulic "muscles" are added. In fact, until the advent of power steering, Saginaw Ball Bearing Screws provided one of the most important advances in automotive steering, and even today most manual steering gears use this principle. Not only in truck, tractor and automotive steering mechanisms but also as actuators in the latest military planes, in the feed mechanism of machine tools and in hundreds of other applications, Saginaw Screws are raising, lowering, pushing or pulling loads up to thousands of pounds with only a fraction of the rotary power requirement of ordinary thread-to-thread screws. The reason: Saginaw Screws transmit the entire rotary-to-linear force through rolling steel balls and thus operate at 90% efficiency with less than 10% friction loss. Saginaw Screws can be combined with electrical, hydraulic or pneumatic units to give an efficient and reliable mechanism for linear actuators that are compact and low in weight-strength ratio. Service and maintenance requirements are remarkably low. Saginaw Screws can be furnished in any size in a complete range of load and life requirements.

For complete information, write for our engineering data book.



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DOUBLE EXTRUSION

Catalogs and Bulletins.....continued

let, 6 pp. Describes a number of air-turbine drives for use in jet and turbo-jet aircraft. Units covered include a 15 hp unit, a 3 hp model, and a 40 hp drive. Has general discussion, operation curves, and other data.

(31) WASHERS—Joliet Wrought Washer Co., Catalog, 8 pp. Has tables listing types and sizes of various washers available, including: wrought washers; SAE washers; riveting washers; machine screw sizes; light steel washers; fender washers; wide and narrow rim mild steel machinery bushing washers. Plus proposed American Standards for apparatus washers, and other helpful data.

(32) DIE CASTINGS—The Hoover Co., Booklet 853, 12 pp. A picture-caption type presentation shows how die castings are made, from the engineering to the x-ray. A section contains hints for designing good die castings, and an informative chart gives chemical and physical specifications.

(33) BACK-UP RINGS—Resistoflex Corp., FR-1, 4 pp. Gives the advantages of Teflon spiral rings for backing up O-ring seals in hydraulic and pneumatic temperatures, particularly at elevated temperatures. With illustrations it contains dimensional specifications, and sizes available.

(34) HYDRAULIC CYLINDERS—Lindberg Engineering Co., Bulletin 701, 28 pp. Has engineering drawings, sizes, capacities, and other data, on 1,500 and 3,000 psi hydraulic cylinders, in bores from 2 to 8 inches. Has material on piston rod heads, mounting brackets, double-end cylinders, and various types of mounting.

(35) TRANSFORMERS & FILTER REACTORS—Essex Wire Corp., Catalog CT-153, 32 pp. Illustrates all models, and gives complete engineering data on: hermetically sealed transformers; new equipment transformers and reactors; general replacement transformers and reactors; control and power circuit transformers.

(36) RELAYS, CONTACTORS, MOTORS—Potter & Brumfield, Catalog 122, 24 pp. Included are relays and contactors for every electrical and electronic application—power, multiple contact, multiple leaf, latch-

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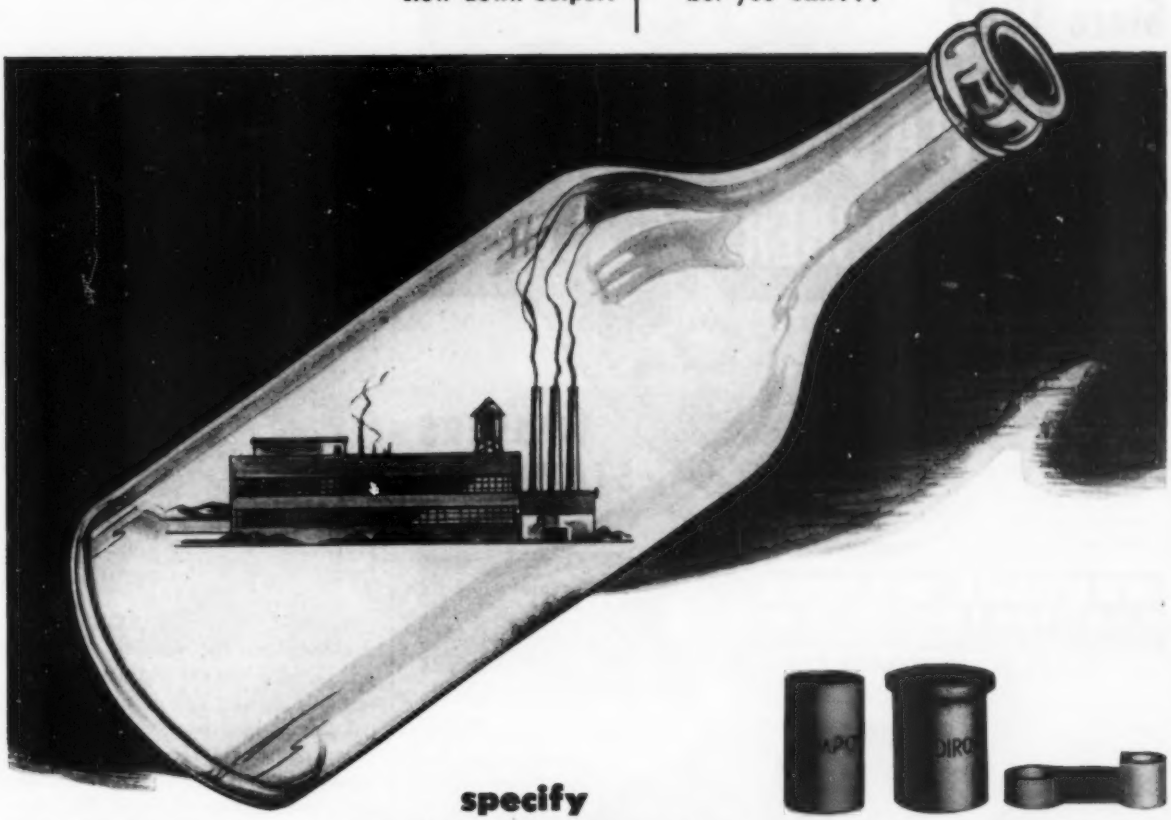

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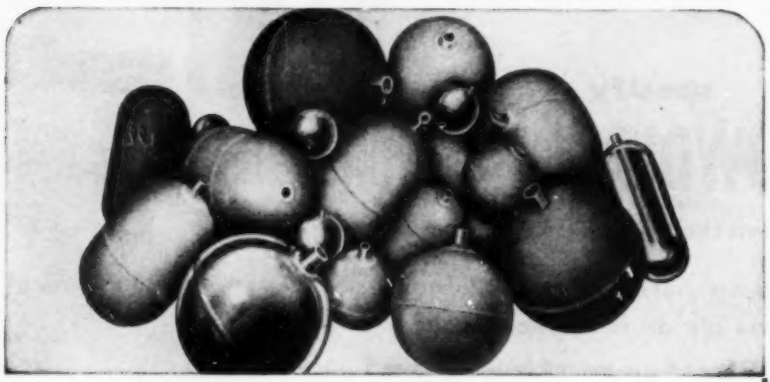

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ing, plate circuit, super-sensitive, and others. Has illustrations, schematic drawings, charts and other data of each model.

(37) MERCURY SWITCHES—Powerex Switch Co., Bulletin M-12, 4 pp. Gives specifications for a line of electrode-to-mercury and mercury-to-mercury type switches operating on voltages of: 10, 125, 250, and 550 v, and with amp ratings from 1 to 30. Has illustrations of these and special types.

(38) SERVO COMPONENTS—Belock Instrument Corp., Catalog, 26 pp. Covers standard electro-mechanical servo and computer components. Descriptions, outline dimensions, and performance data are given on high speed magnetic clutches, servo gear heads, speed reducers, dial assemblies, limit stops, and differentials. Gears in pitches from 32 to 96 with hub bores from $\frac{1}{8}$ to $\frac{1}{4}$ inch.

(39) AIRCRAFT HARDWARE—Air Associates, Inc., Catalog 21 a, 240 pp. Divided into two sections, the first section illustrates and describes in detail aircraft hardware items, including nuts; bolts; rivets; clips; clamps; pins; turnbuckles; pulleys; washers; rod ends; fasteners and fittings. The second section has reprints of the original AN specifications, with dimensions of parts.

(40) PROTECTIVE RELAYING—General Electric Co., Booklet GET-1768 A, 72 pp. Titled, "The Art of Protective Relaying," it explains the broad principles of practice in protective relaying of power apparatus, and has information on the types of relays used for protecting various apparatus. It outlines procedure to determine proper application and settings of relays, and gives a complete listing of different relays. Has many illustrations of the various relays and circuit diagrams.

(41) ADJUSTABLE-SPEED DRIVE—Reliance Electric & Engineering Co., Bulletin D-2102, 12 pp. Data and illustrations on a new electronic adjustable-speed drive of from $\frac{3}{4}$ to 3 hp for small industrial equipment. These adjustable speed drives use no mechanical devices, cone pulleys, gear boxes, clutches or mechanical brakes.

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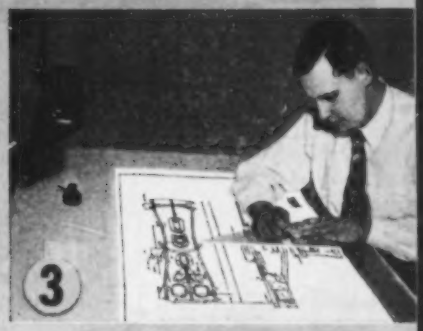

A positive Repro-Negative print is made from the corrected negative... on this the draftsman adds the new design... and a master is ready to produce the required number of prints. *Ready* in a fraction of the time required previously when the unchanged design was retraced in full.

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- Kodagraph Autopositive Cloth is used to reproduce new pencil drawings directly, which helps eliminate costly ink tracing.

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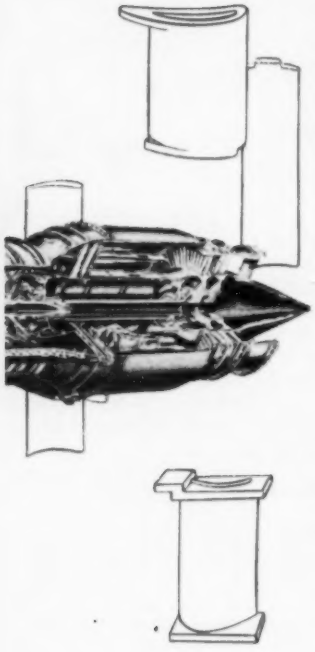

Oddly enough, the metal fabricating process first used to produce cobalt-chrome dentures helped put the "bite" into World War II bombers. The tiny power blades in the turbo-superchargers of high-flying B-17's and B-29's that provided extra speed and longer range were precision cast from high-temperature alloys by the unique Microcast Process.

Originated in 1929 by Austenal Laboratories, Inc., to cast non-machineable alloys, the Microcast Process today is used to produce parts and components from a wide range of ferrous and non-ferrous metals.

The Microcast Process offers exceptional opportunities in the mass production of parts and components. Product improvement through the use of better alloys, economies through the elimination of expensive machining operations, and greater freedom of part design are only a few of its advantages. Investigate Microcast today . . . it may well be the means of a better product at lower cost for you.

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U. S. Engineers Cooperative In Lend Lease

To the Editor:

I am greatly indebted to *Product Engineering* in helping me obtain certain control data from Curtis-Wright Corporation. They were most helpful and extremely courteous, and gave me the full particulars that I desired.

I have been a fairly frequent visitor to the U.S.A. over the years, and, in fact, have only just returned from there. These visits have invariably been pleasant in every respect because of the generous and helpful attitude that top men have shown, whenever I have visited the country.

May I again thank you for your kindness. —FRANK S. DALEY

General Technical Manager
Kelvinator Australia Ltd.
Keswick, South Australia

Defends Scientists In Guided Missile Program

To the Editor:

I have just seen your well-written article on the Guided Missile Program. One point, however, needs some clarification.

A great deal of optimism is held by competent missile scientists regarding the feasibility of both SSM (surface-to-surface) and GGM (ground-to-ground). These same men, however, take a very pessimistic view of the Military's handling of these vital programs. Efforts by civilian coordinators such as K. T. Keller, Chairman of the Board of the Chrysler Corp., have been the only bright spots evident. My observations are based on experience and associations during Draft service with the Ordnance Corps in the Guided Missile Center at Redstone Arsenal, Huntsville, Alabama.

The reason qualified engineering personnel shy away from relatively

high paying positions in this field is simply historic military mismanagement and incompetence.

As you may have guessed, my experiences at Redstone Arsenal have some sore spots. It is unfair to the many brilliant technical men in these programs to have failure thus far chalked up wholly to technical difficulties. —JAMES L. PUSCH

Research Report Well Liked

To the Editor:

I have received your June issue of *Product Engineering* and was very much impressed with your 32-page article titled, "Insuring Your Progress Through Research."

It seems to me that this article is a natural for a reprint, and if you have done so, I would like to have several copies of it. —E. F. BRISSIE
Doehler-Jarvis Div.
National Lead Co.

Ed—Under separate cover we are sending you a dozen copies of the article, "Insuring Your Progress Through Research."

An Unanswered Letter

While on an extended trip I received a letter that I cannot answer because of the lack of an address. And perhaps the gentleman who wrote it doesn't want me to answer it. However, I do feel that he should receive an answer, so this is it.

The reader wrote in, "After reading your April editorial I couldn't help dropping you this note. (The editorial referred to is, 'A Graduate Can Measure A Bottle' and took to task engineers who unnecessarily resort to a lot of complicated mathematics whereas a simple test or experiment will give the answer.) Please do not fire too heavy a broadside at mathematics. My mathematical thinking is the biggest human asset I have, as an engineer.—J.P.L."

I want to assure Mr. J.P.L. that the ability to think mathematically is not only an engineer's greatest asset but also a great asset for any and every person. Few people can think "mathematically". The only purpose of the editorial was to send out a warning

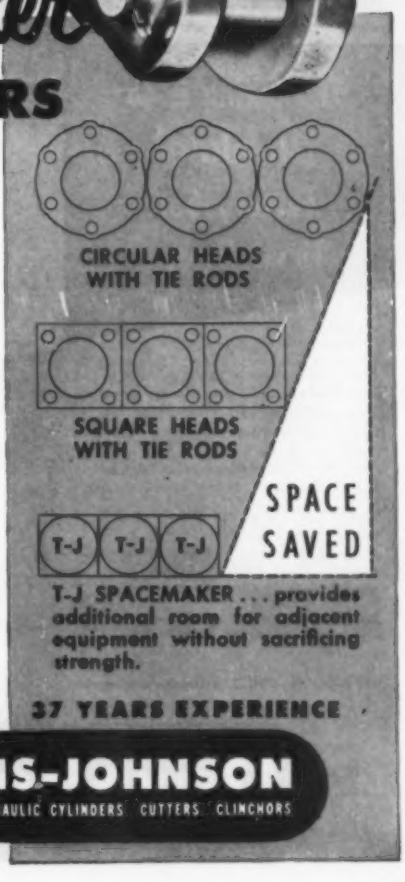
LESS SPACE!

extra high safety factor!

NEW T-J Spacemaker AIR CYLINDERS

These new T-J Cylinders *save up to 40% in mounting space*—with streamlined design that eliminates tie rods. They're *super rugged*—extra high safety factor . . . solid steel heads . . . heavy wall, precision honed, hard chrome plated, seamless steel body . . . leakproof cylinder head to body construction . . . heavy duty, hi-tensile, hard chrome plated piston rod.

Available with the new T-J Super Cushion Flexible Seals which insure positive cushion with automatic valve action for fast return stroke. Many standard sizes and styles . . . for pushing, pulling, lifting, clamping or control jobs. T-J dependability. Write for bulletin 8152. The Tomkins-Jounson Co., Jackson, Mich.



T-J SPACEMAKER . . . provides additional room for adjacent equipment without sacrificing strength.

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RIVITORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHORS

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Switching Unit
Moves 3 Cars at a Time!

Here's a practical "locomotive" for switching and spotting cars on your sidings — at a great saving in man-hours, plus increased safety and ever-ready convenience . . . at an operating cost of about 1½ gals. of gasoline per hour!

A 25 hp. Model VF4 Wisconsin Heavy-Duty Air-Cooled Engine furnishes dependable power for all phases of HEMCO-MOTIVE operation . . . off-track mobility, climbing up and over the rails, operating the hydraulic lift that "couples" the unit to the car, and handling all switching and spotting maneuvers . . . delivering a 7400-lb. drawbar pull through 4-wheel drive, moving up to 3 loaded freight cars at a time, at a rail speed of 150 ft. per minute! Hemco Manufacturing Inc., Argonia, Kansas, is the builder.

It's another typical Wisconsin Air-Cooled Engine original equipment application . . . again illustrating how these fine engines fit both the JOB and the MACHINE.

WISCONSIN MOTOR CORPORATION
World's Largest Builders of Heavy-Duty Air-Cooled Engines
MILWAUKEE 46, WISCONSIN

The Swing is to Durakool Factory Set Timer Relays

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Practically non-breakable, Durakool **Factory Set Timer Relays** have more than proved themselves on the roughest and toughest jobs that could be found. Year by year, their use increases in sensational fashion.

Controlled time available from .15 to 20.0 seconds in either normally open or normally closed actions. No waiting. Your production schedule is met.

See telephone directory for local distributor or write for Bulletin 800

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★ No false contacts
★ No chatter
★ Quiet in operation
★ Low in cost

Durakool ALL-STEEL MERCURY *Timers*

against excessive and useless mathematical operations just because we have wonderful machines with computers and we want to use those machines at every possible moment. In other words, a computer should not be looked upon as a toy. There is no sense in making mathematical computations if the answer can be obtained just as quickly and as accurately by a graduate glass of some other simple experimental method. —GFN

Color Blindness and Color-Coded Wire

To the Editor:

I read with great interest the article in the June issue on Color Coding of Electrical Wire.

As Production Design Engineer, I made a study in May of the value of color coding wire and came up with the survey and report shown below. It was startling to me to find such a situation, and I found that even some of our inspection and liaison personnel are "color-blind."

You might be interested in passing this study on to your readers as a warning to the industry concerning color coding; especially to companies who are making items which have a high and critical maintenance factor.

In addition, and having no relation to the survey, coding wires by marking the white insulation with a wire run number is a very flexible and satisfactory method. It eliminates the stocking of many colored wires which, in a complicated aircraft, would not nearly take care of the requirements for identification.

Color Blindness Relative to Use of Color-Coded Wire

1. The prevalence of color-blindness among male employees should be considered when using color coded wire for electrical equipment.

2. Color wire is being used in some aircraft and an attempt is being made to standardize on the color shades from different manufacturers. If it is remembered that the basic colors are used, white, black, red, yellow, orange, green, violet, brown, blue and gray, it will eliminate misinterpretation of shades.

3. But, nothing will help a "color-

You can't see SYNTHANE but it's in the picture

There are important factors about picture-making you never see in the print—the photographer, the lights, the darkroom, the chemicals. One of many materials essential to photography is Synthane—a laminated plastic.

Synthane is corrosion-resistant . . . Synthane spools carry film from early stages of emulsion coating through developing. Synthane is opaque to infrared rays which accounts for its use as slides for film packs. Synthane is an electrical insulator; you'll find it hidden in flash guns, lighting equipment and projectors. Synthane is wear-resistant and vibration-absorbing, fine for quiet gears in movie cameras.

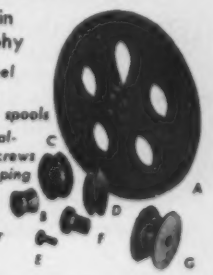
The photographic industry is only one part of the American industrial picture, and the properties for which Synthane is valued in it are only a few of the many Synthane has. Others are good tensile, compressive, flexural, and impact strengths, dimensional stability, light weight, high dielectric strength, ease of machining. Synthane has all these properties—and more—in combination. And the combination may be valuable to you.

To get the complete picture of Synthane and its possible place in your product, write today for the 24-page Synthane Catalog. Synthane Corporation, 6 River Road, Oaks, Penna.

Here you see the three basic forms of Synthane laminated plastics—sheets, tubes and rods. All three are made by applying heat and high pressure to resin-coated laminations of paper, fabric, glass cloth or mat. Synthane is thermo-setting, has many much-sought properties in combination.

Synthane in Photography

A—16mm Reel
B,C,D—Film processing spools
E,F—Chemical-resistant screws for developing equipment
G—35mm film carrier



Synthane—one of industry's unseen essentials

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LAMINATED PLASTICS

LEBANON Castings
are at work

SPANIARDS marvel at these Talgos that flash by on the Madrid to San Sebastian run. Developed by Spanish and United States designers, built by American Car & Foundry Company, the Talgos are more than streamliners. They are an entirely new concept in railroading! The economical, light-weight Talgos hug the rails, safely rounding curves at 80 to 90 MPH, reaching 130 MPH on the straight-a-ways. And *all* the alloy castings in these remarkable trains are Lebanon CIRCLE Ⓛ . . . 22 for each train*.

In programs requiring creative effort you'll find Lebanon engineers and metallurgists working directly with the designers to produce castings with outstanding characteristics. Such a program created *the Talgo . . . el tren de mañana!*

See—STEEL WITH A THOUSAND QUALITIES—37 min., full color sound film on the making of steel castings. For information write: Dept. C, Lebanon Steel Foundry.

*Made of CIRCLE Ⓛ 205, a light-weight, strong and tough alloy. Typical castings are illustrated above.

LEBANON Castings
CARBON, SPECIAL ALLOY AND STAINLESS STEEL

LEBANON STEEL FOUNDRY LEBANON, PA.

blind" person. He will see reds and greens as grays or "dark" colors. In some cases (rarer than others) the blues and yellows appear gray.

4. All of us at times, and under various light conditions, see the reds and greens as shades of gray, and even under ideal conditions many of us still do not see these colors in their full brilliance. About 8 percent of the males and ½ percent of the females are known as "color-blind." They see red and green as a definite shade of gray and are not even able to discern between the two. One in several thousand is blue-yellow color blind, seeing these colors as shades of gray.*

5. A test was run on the identification of 15 pieces of color coded wire and the people were picked at random from among the electrical shop and engineering personnel. Twelve people were tested. None appeared to be Color-blind, although violet appeared as black to some, and green appeared to be blue. Also, one man saw red and orange as brown, especially against a green or blue background.

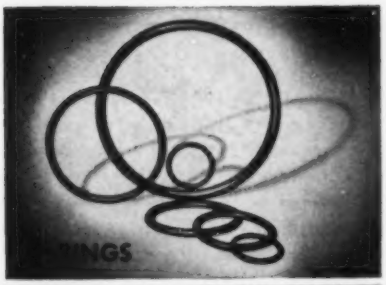
6. As a comparison, two men known to have color deficiencies were asked to check the samples. Most reds and greens appeared gray or an unidentifiable dark color. The orange appeared red and brown in some cases, and the violet showed as black.

7. From these samplings it was readily seen that it is necessary to be sure people who work on color items are free from any color deficiency. Even should they be able to match colors, (some color blind people cannot even do this), they would not be able to wire or inspect wiring, for they must be able to choose a color as designated by its name on the wiring diagram.

8. With the percentage of color blindness so high, it is believed that the use of color coded wire should be discouraged. Where it is required by contractual specification to use color coded wire, the workmen should be checked and passed for color blindness. Not only will this qualifying procedure insure correct workmanship, but it will relieve from embarrassment the color blind person who would tend to make color errors.

*(These statements from the 1952 Science Journal.)

—CHARLES DE LAHAYE
Production Engineer
McDonnell Aircraft Corp.



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RADIATION ABSORBERS

NAVAL RESEARCH LABORATORY of the Office of Naval Research reports new microwave absorbers in the form of fibrous mats impregnated with pigmented rubber solutions. These materials have given efficient broadband absorption over the range of 2,500 to 35,000 megacycles, reflecting less than 5 percent as much as a smooth metal plate.

After testing many combinations—including excelsior, curled vegetable fiber, curled and uncurled animal hair, with aluminum flakes, graphite or conducting carbon black in rubber solutions as the loss-producing pigment—scientists found that rubber-bonded curled animal hair formed the best combination. Reasons: flexibility, resiliency, and resistance to mechanical abuse and normal weathering conditions. Also it uses relatively inexpensive materials that are available commercially in large quantities.

Chief disadvantages of this absorber, named "Darkflex", are: 1) it is flammable and 2) the thickness and density of curled animal hair sheets are not subject to close control in normal production. Considerable variation is possible even in a single small sheet.

Bulkiness is another disadvantage for broadband application, since the minimum thickness is about a quarter of the longest wavelength to be absorbed. Less bulky types have been developed, however, which are applicable to particular bands, such as the K-band, and the K- and X-bands.

CHINESE ENGINEERING STUDENTS

ALMOST HALF THE NEW STUDENTS admitted to colleges this year will be assigned to engineering courses the Chinese Communist government recently announced. According to the official Peiping statement, this year's freshman class will be divided this way: in engineering, 43.3 percent; teaching 26.1; public health 10.3; sciences 6.4; others including the arts, fine arts, and law make up the remainder.

Communists claim that there are 219,700 students now enrolled in institutions of higher education in the country. Last year, 65,893 students entered colleges; 51 percent of these were assigned to study engineering.

Edison—
...First to make a successful incandescent lamp
Thomas Alva Edison
1847-1931
One of the most prolific inventors of all time, this gifted American developed 1,033 patents during 50 years of continuous work. Among these was the "electric light," a carbonized cotton filament incandescent lamp, successful for the first time on Oct. 21, 1879. Edison died at 84, after receiving every honor a grateful world could bestow.

From an original drawing made for Ohmite

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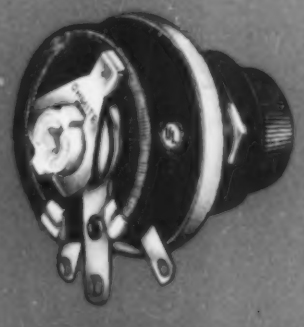
Industry buys more Ohmite rheostats than any other make... and for good reason! Unmatched smoothness of operation and close, dependable control have made Ohmite rheostats the standard in their field. The special Ohmite design features insure unfailing dependability. Ten wattage sizes in a variety of types provide a wide range to suit your every need. You can specify Ohmite... with the confidence that comes in knowing you use the best.



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RHEOSTATS • RESISTORS • TAP SWITCHES

What Special Feature do you need in a RHEOSTAT?

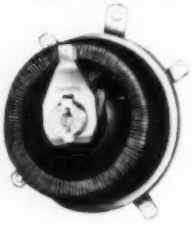
OHMITE CAN SUPPLY IT!

In addition to standard rheostats, Ohmite offers rheostats with a wide variety of *special features*. All have the distinctive Ohmite design features: smoothly gliding metal-graphite brush; all-ceramic construction; insulated shaft and mounting; windings permanently locked in place by vitreous enamel.

BUSHINGS FOR SPECIAL PANEL THICKNESS

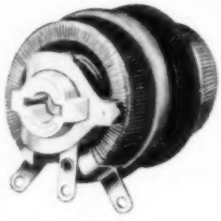
Extra-long bushings and shafts allow mounting on panels up to 2 inches in thickness. Seven bushing lengths are available, from $\frac{1}{4}$ to $2\frac{1}{8}$ inches.

360° WINDING



Two small models available with continuous circular core and endless winding. Unlimited rotation of shaft and contact arm. Taps supplied at any desired angle on windings.

DEAD LUG OFF POSITION



Opens the circuit at the high or low resistance position as the contact passes on to the lug, which is disconnected from the winding. Recommended for light duty.

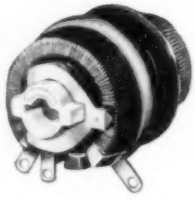
SCREW DRIVER SLOT SHAFT

Where infrequent adjustments are needed, shaft ends can be slotted for operation with a screwdriver. Tampering with the shaft setting is thus minimized.

SEALED, ENCLOSED CAGES

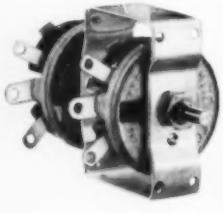
Compact, corrosion-resisting metal enclosure, permanently sealed by a double seam, protects the unit completely. Available with rheostat Models H and J.

SNAP-ACTION OFF POSITION



Opens the rheostat circuit at the high or low resistance position. The circuit is opened as the brush snaps into an insulated notch next to the lug, providing indexing.

TANDEM ASSEMBLIES

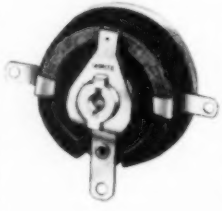


Ohmite rheostats can be mounted two or more in tandem, for simultaneous operation of several circuits. Universal joints provide smooth, positive mechanical action.

TOGGLE SWITCH

Toggle switch is operated with a positive snap by the movement of the contact arm. Opens the rheostat circuit or switches an independent circuit. Available for all models.

LESS THAN STANDARD ROTATION



Rheostats can be supplied with winding space and angle of rotation less than standard. Rheostats can also be supplied with fixed or adjustable stops.

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RHEOSTATS • RESISTORS • TAP SWITCHES

NEW BOOKS

Fundamentals of Physical Science

KONRAD BATES KRAUSKOPF, *Professor of Geochemistry, Stanford University. 694 pp, 6 x 9 in. Published by McGraw-Hill Book Company, 330 West 42nd St., New York 36, N. Y. $6.*

This is a revision, the third edition, of a well known text written for the non-science student. In it are described many of the phenomena of science—physics, chemistry, astronomy and geology—in non-technical terms so that the student can obtain some understanding of technical developments.

Changes in the new edition include: 1) bringing up-to-date primary material on atomic nuclei, atomic energy, cosmic rays, and the earth's interior; 2) adding new sections on electronics, silicones, and recently expressed theories on the origin of planets; 3) new up-to-date illustrations; 4) adddition of new problems for the student to solve.

Behind the Scenes Of Business

ROY A. FOULKE, *Vice President of Dun & Bradstreet. 200 pages, 5½ x 8½ in. Published by Dun & Bradstreet, Inc., 99 Church St., New York 8, N. Y.*

Any engineers who have in mind they are going into business and those engineers who are now concerned with the operation of a business will find much food for thought plus a wealth of basic data and information in this excellent book, "Behind the Scenes of Business". Mr. Foulke has written the book in an extremely clear, easy flowing manner. He makes considerable use of anecdotes and parables.

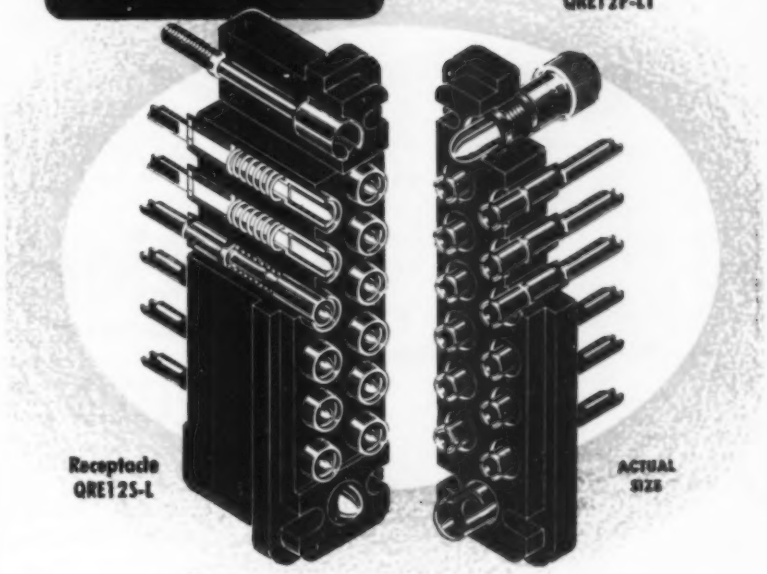
Successive chapters of the book deal with management responsibilities and the establishment of sound policies, financial analyses and their application to capital, inventory, sales and net profits. Another chapter deals with the elements of successful management under competitive and adverse conditions.

In the opinion of the reviewer, per-

Winchester Electronics

"L.T." indicates knob-actuated locking. Knob (LT) may be on either plug or receptacle.

Plug QRE12P-LT



Receptacle QRE12S-L

ACTUAL SIZE

QRE CONNECTORS

for HIGH CURRENT
HIGH ARC RESISTANCE
HIGH DIELECTRIC
RUGGEDNESS
COMPACTNESS
QUICK DISCONNECT

High acceptance is also a feature of Winchester Electronics' Connectors resulting from the exceptional service they give in critical applications. These patented* Connectors have the following **SPECIAL FEATURES:**

POLARIZING: Heavy guide pilot and socket insure self-alignment of contacts as well as polarization.

SELF-ALIGNING: Individually floating contacts assure self-alignment.

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PRECISION MACHINED CONTACTS: Pins from brass bar (QQ-B611) and sockets from spring temper phosphor bronze bar (QQB-746a). They are gold plated over silver for consistent low contact resistance, reduction of corrosion and ease of soldering.

MOLDED MELAMINE BODIES: (MIL-P-14) Mineral-filled and fungus-proof. Provide mechanical strength as well as high arc and dielectric resistance.

MONOBLOC† CONSTRUCTION: Eliminates unnecessary creepage paths, moisture and dust pockets, and provides stronger molded parts.

HOODS, CONNECTOR CLAMPS AND MOUNTING BRACKETS AVAILABLE.

WINCHESTER PRODUCTS AND WINCHESTER DESIGNS ARE AVAILABLE ONLY FROM WINCHESTER ELECTRONICS, INCORPORATED.

QRE Connectors are available with 6, 12, 18, 24, 34 and 208 contacts.
*Patent Number 2,486,370 †Trade Mark

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'DIAMOND H' RELAYS

Shown Actual Size

...now even **mightier** midgets

NEW CHARACTERISTICS engineered into famous "Diamond H" Series R Relays have now broadened their adaptability for such applications as guided missiles, jet aircraft, fire control and fire detection, radar, communication, high speed camera, geophysical and computer apparatus . . . wherever positive operation is demanded under critical conditions.

A 4PDT hermetically sealed, miniature aircraft relay basically, they are now also available DPDT with two independent coils, either or both of which will operate the units.

In their field still the smallest and lightest, (1.6 cu. in. 3.76 oz.) combining highest operating shock resistance (to 50 "G" and higher), widest temperature range (−65° to + 200° C.) and greatest ability to break high currents and high voltages, Series R Relays consistently operate over 400,000 cycles without failure at 5 A. and go 3,500 or more under 30 A. at 30 V., D.C., resistive. They carry voltages up to 300 D.C. at 4/10 A. for more than 400,000 cycles. With low contact loading, life expectancy is 10 million cycles or better.

Operating time is 10 ms. or less; drop out time 3 ms. or less. Coil resistances up to 35,000 ohms are standard; to 50,000 ohms available for special units. Sensitivity approaches 100 mw. at 30 "G" operational shock resistance. Inter-electrode capacitance is less than 3 mmf. contacts to case—less than 2½ mmf. between contacts, even with plug-in type relay and socket. Vibration range is from 0 to 500 cycles per second and upward at 15 "G" without chatter.

All standard mounting arrangements, including ceramic socket, are available. Uniquely simple design permits compact grouping . . . and a firm bond between relay and chassis.

Designed to meet all requirements of USAF Spec. MIL-R-5757B, they far surpass many. Bulletin R-150, giving basic performance data under varying conditions, is yours on request. Our engineers are prepared to work with you to develop variations to meet your specific requirements. Tell us your needs.

THE HART MANUFACTURING COMPANY

206 Bartholomew Avenue • Hartford, Connecticut

haps the most interesting chapter is one which has been added to this revised edition, entitled, "The Relativity of the Moral Hazard". This chapter dwells considerably on the "fatal affinity between business failures and commercial fire losses", and is followed by a chapter on "Old Age of the Business Enterprise" in which Mr. Foulke describes and explains the evidence, reasons and results of debility of an enterprise. "When they (management) begin to grow slightly lax in their interest in technological improvements . . . when their sole concern is concentrated on the maximum of immediate profits; when the amount of yearly combustion decreases not only physically but also mentally; then if that management delays in giving way to more wide awake, more scientifically adept, more active successors, old age has crept in."

Fittingly, the final chapter of this revised edition deals with the preparations for tomorrow.

Of tremendous interest is the compilation of fourteen important ratio figures that are based on the yearly figures of seventy lines of business activity among many thousands of manufacturers, wholesalers and retailers. The fourteen ratios include current assets, net profit and net sales, net profit on tangible net worth, average collection period in days, net sales to inventory and similar ratios.

Review of Current Research and Directory Of Member Institutions

Edited by E. V. NEILLY, *Secretary, E.C.R.C., 330 pp, 6 x 9 in., paper bound. Published by Engineering College Research Council of the American Society for Engineering Education, 103 Mechanical Engineering, Pennsylvania State College, State College, Pa.* $2.50.

Every two years the Engineering College Research Council publishes a detailed report covering the research projects conducted at member institutions. This is the most recent edition, dated June 23, 1953.

Each of the 103 member colleges—including all the major engineering schools in the United States—reports the following information: 1) proper mailing address, 2) responsible re-

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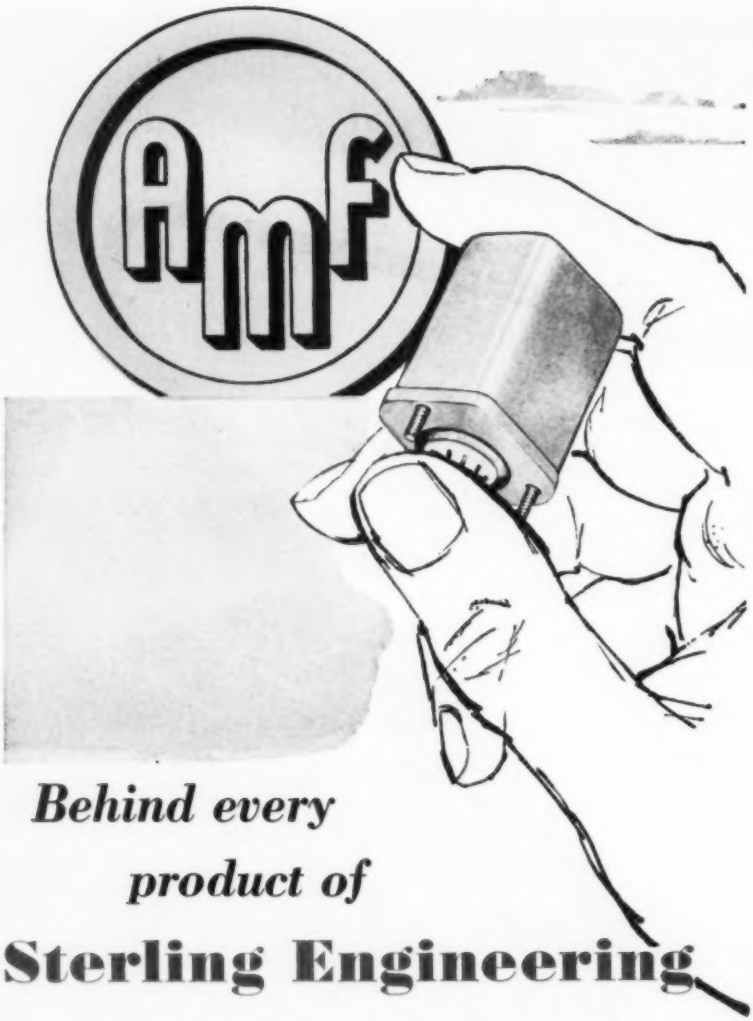

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search authorities, 3) research policies, 4) number of research personnel, 5) annual research expenditures, 6) annual research income, 7) short courses and conferences held at the school and 8) current active research projects classified according to field.

To indicate the scope of this edition—it reports 5,000 research project subjects, costing an estimated $65,000,000 per year. Copies may be obtained by writing the Council Secretary who edited the report.

Management Controls in Industrial Research Organizations

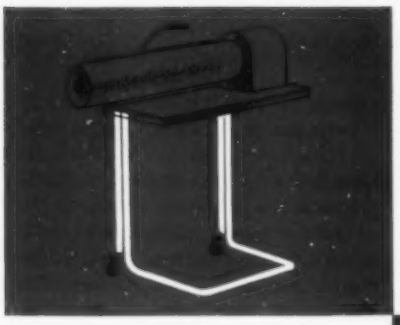
ROBERT N. ANTHONY, *Associate Professor of Business Administration, assisted by John S. Day, Research Associate, Division of Research, Graduate School of Business Administration, Harvard University.* 5½ x 8½ *in.* 637 *pp. Published by Harvard Business School, Division of Research, Soldiers Field, Boston* 63, *Mass.* $6.75.

This book is a study of management control practices in industrial research organizations—written primarily for persons who manage such organizations.

Part I, *Statement of the Problem,* focuses the attention of the reader on the particular aspects of research management to be included in the study. In Part II the reader's attention is directed to *Factors Which Relate to the Problem.* Part III treats current control practices within a functional classification. Four chapters, describing in detail the current control techniques in four specific industrial laboratories, compose the concluding part of the study.

The author's descriptions of and comments on current control practices refer to a large number of actual laboratory situations in industrial research. Many of these are presented in such a manner as to permit the reader to make his own observations about the practices described.

The nature of the research worker and the research process demands of the individual who shoulders the responsibility for management of the research program broad technical qualifications, highly developed administrative skills, and a perspective that arises from an admixture of both. Top man-



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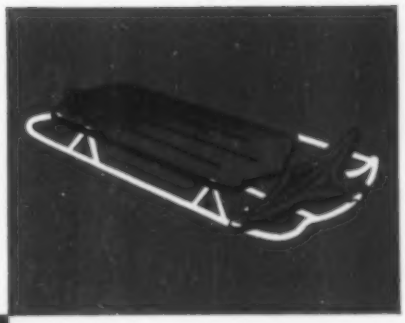

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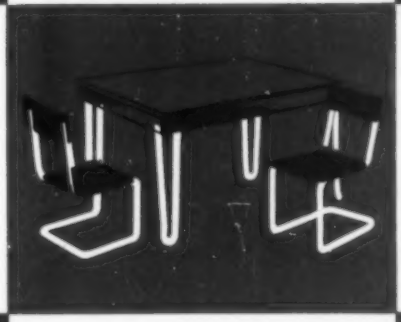

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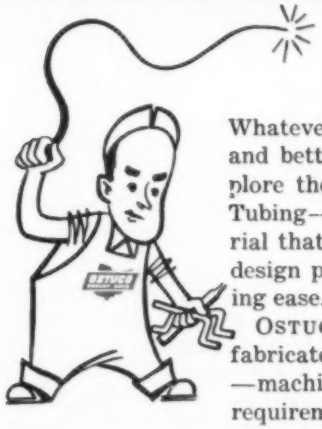

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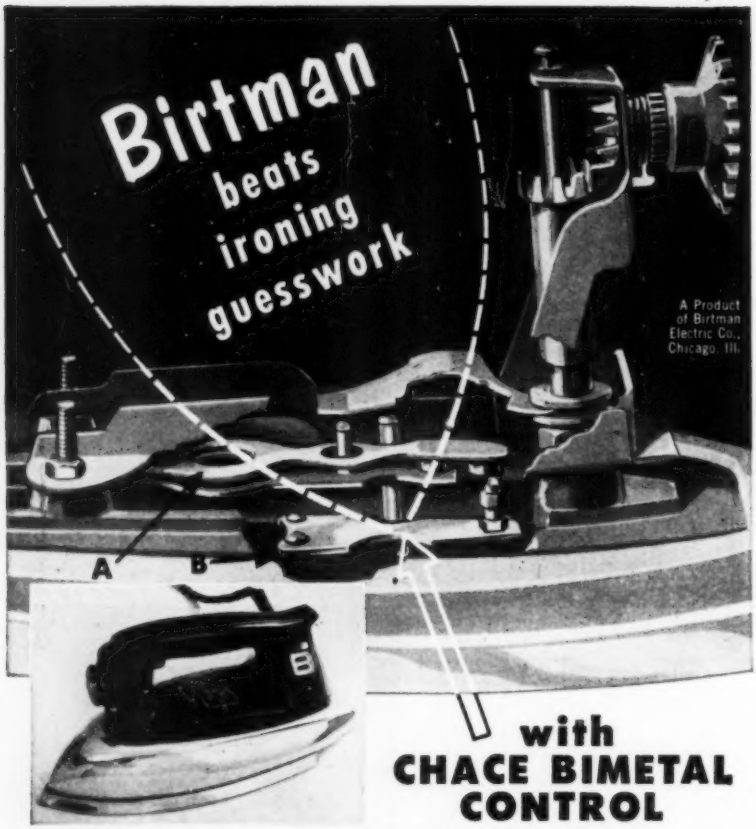

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agement has found it necessary actively to seek out persons who possess such qualities and to delegate to them responsibility for the company's research program.

These research administrators have at least three objectives, broadly defined. One is to develop a basis for securing for the research organization the necessary resources to enable it to attain its goals, however defined.

Another objective is to be an effective administrator within the laboratory. The author describes the management control problem as an important part of this activity. He lists three major things that research management must do here: (1) decide the program and the resources to be used to carry out the program; (2) check up and appraise the performance of the organization in carrying out the program; and (3) create a set of procedures which will assist in the planning and checking up functions and in operating under the program.

A third objective is to be an effective member of top management as it seeks to discharge its obligation for planning for the long-run health of the whole industrial organization.

An understanding of the techniques of control and a wise use of these devices has been of great value in helping research administrators attain these objectives. The expenditure of additional time in active contemplation of the extent and use of control techniques within their own research organization promises to repay many present-day research executives amply.

Pumps

FRANK A. KRISTAL, *N. Y. District Mgr., Weinman Pump Mfg. Co.*, ROY E. ROTH, *Wagener Steam Pump Co., and* F. A. ANNETT, *Contributing Editor, Power.* 6 x 9 *in.*, 373 *pp. Published by McGraw-Hill Book Co.*, 330 *W. 42nd St., New York* 36, *N. Y.* $6.50.

Here are the A B C's of pumps of many types and designs—a complete, practical treatment that explains what kinds are available, how to select and install them, how to operate and maintain them, how to locate and remedy pump troubles.

A wide range of pump applications are discussed, including boiler feed, paper stock, deep well, sewage

and sludge, chemical, food product, oil field, gasoline line, fire, corrosive, mine, etc.

Performance features of the various types of pumps are fully and clearly explained, as well as their service limitations. You learn construction features, materials used in manufacture, and essential details about the operation of the particular types of pumps in which you are interested.

Aids are presented for stating pump requirements to pump manufacturers —also practical methods for figuring the head, economical pipe sizes, various pump combinations, etc.

The types of pumps that are discussed include the following: reciprocating; Volute-type centrifugal; Diffuser-type centrifugal; Turbine; Propeller, Rotary (including gear and others); Deep-well; Boiler-feed; Sewage and sludge; Sanitary; and Variable displacement and proportioning.

Textbook of the Materials of Engineering

HERBERT F. MOORE, *Research Prof. of Eng. Materials, Emeritus, Engineering Exp. Sta., Univ. of Ill., and* MARK B. MOORE, *Assoc. Prof. of M.E., Rutgers Univ.* 6 x 9 *in.*, 372 *pp. Published by McGraw-Hill Book Co.*, 330 *W. 42nd St., New York* 36, *N. Y.*

This is a revision and modernization of a leading text in the field. Concise presentation is made of the properties of various materials, used for machine and structural parts, which affect the strength, stiffness, ductility, and resistance to corrosion or wear.

The coverage of these properties includes methods of production such as casting, molding, etc., and chemical and mechanical methods of strengthening materials: heat treating, alloying, hammering and rolling, and aging. The internal structures and processes producing various materials receive brief descriptions. Effectiveness of various treatments for structural or machine parts is demonstrated, along with the limiting stress, strain, or strain energy under which various metals function satisfactorily.

This new edition offers recent information given by the electron microscope, a slight discussion of resistance to "fatigue" by metals under compressive loads, discussions of Boron and Titanium, pre-stressed and

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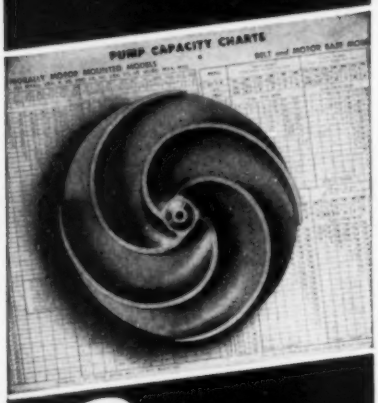

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This volume is especially suitable for classroom work because of its convenient length, superior organization, and concise presentation.

Mechanical Engineering Thermodynamics

DAVID A. MOONEY, *Principal Mechanical Engineer, Jackson & Moreland, Engineers. 6 x 9 in., 540 pages. Published by Prentice-Hall, Inc., Fifth Ave., New York 11, N. Y.* $9.35.

This is an introductory book on the principles of thermodynamics and their applications in mechanical engineering, with sufficient descriptive matter on heat engines included for those who have not studied the subject.

Thermodynamics is treated as a logical formulation of facts known from experience. The general order of presentation is: basic concepts, principles, data on substances, engineering applications. The basic concepts of work and heat are discussed in detail, with a number of examples included as a prelude to the subject matter of later chapters.

Headings of the chapters, in order, are: work; temperature and heat; properties of systems; the first law of thermodynamics; flow processes—first law analysis; the second law of thermodynamics; basic applications of the second law; properties of pure substances; tabulated properties—steam tables; properties of gases; properties of gaseous mixtures; process calculations for stationary systems; vapor cycles—the Rankine cycle; vapor cycles—more efficient cycles; gas cycles; fluid flow—nozzles and orifices; turbines; reciprocating expanders and compressors; the steam engine; gas compression; combustion processes—first law analysis; internal combustion power plants; refrigeration; and air-water vapor mixtures.

The properties of substances are presented first from a general viewpoint, using plots to show the relation-

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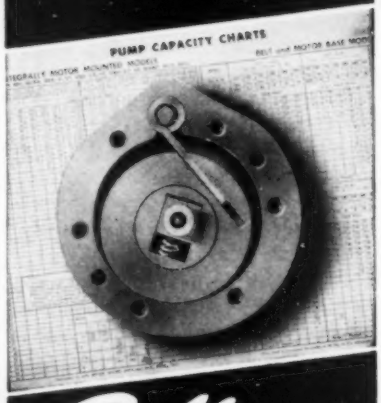

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ships among gaseous, liquid, and solid states. Then the special methods of handling data are explained; steam table data, perfect gas data, and modified gas law data, including gas tables are discussed.

In the chapters on applications, the approach is always from the thermodynamic rather than the descriptive viewpoint.

Introduction to Geometrical and Physical Optics

JOSEPH MORGAN, *Prof. of Physics, Texas Christian University.* 6 x 9 *in.*, 450 *pp. Published by McGraw-Hill Book Company,* 330 *W. 42nd St., New York* 36, *N. Y.* $6.50.

Engineers who, on occasion, must apply optical phenomena will find this text an easily understandable reference. Designed to serve in college intermediate physics courses, the book offers a general comprehensive treatment of the field, developing the basic principles of geometrical and physical optics, and then illustrating them with typical applications.

The first third of the book is devoted to geometrical optics—discussing the phenomena of reflection and refraction and the observation that light travels in a straight line. Study of reflection covers the subject of mirrors; study of refraction leads to the development of the various types of lenses and their equations.

In the remainder of the text, physical optics is the predominant subject. This phase of optics is based on the corpuscular and wave theory of light. The wave theory is used to explain light interference, diffraction and polarization. It is the basis of spectroscopy and spectographic analyses. The corpuscular theory—Planck's quanta or photons—best explains the photoelectric effect and the dispersion and absorption of light.

Applied Electricity

H. COTTON, *Prof. of Electrical Engineering, Nottingham Univ.* 6 x 9 *in.*, 482 *pp. Published by The Industrial Press,* 148 *Lafayette St., New York* 13, *N. Y.* $4.50.

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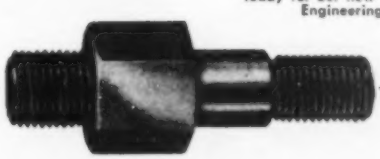

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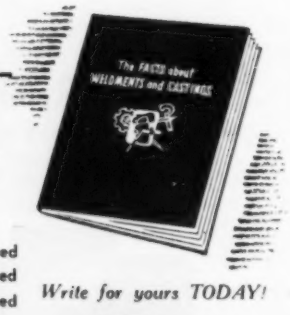

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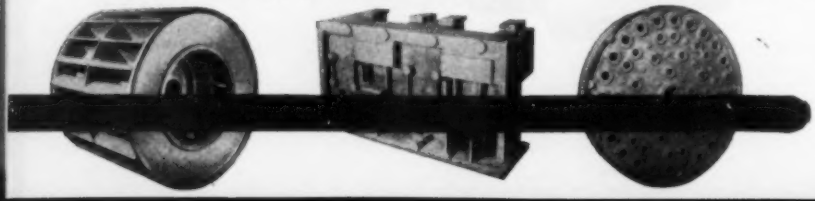


text that has already proved to be popular among both students and practicing engineers in England. It features (a) completeness—the coverage is such that most students will want to retain it for reference when they have graduated; (b) adequate treatment of basic principles, minimizing reference to other works; (c) well-drawn diagrams and highlighting of important formulas by outlining in box fashion; and (d) plenty of worked-out examples in the text with further problems provided for student practice.

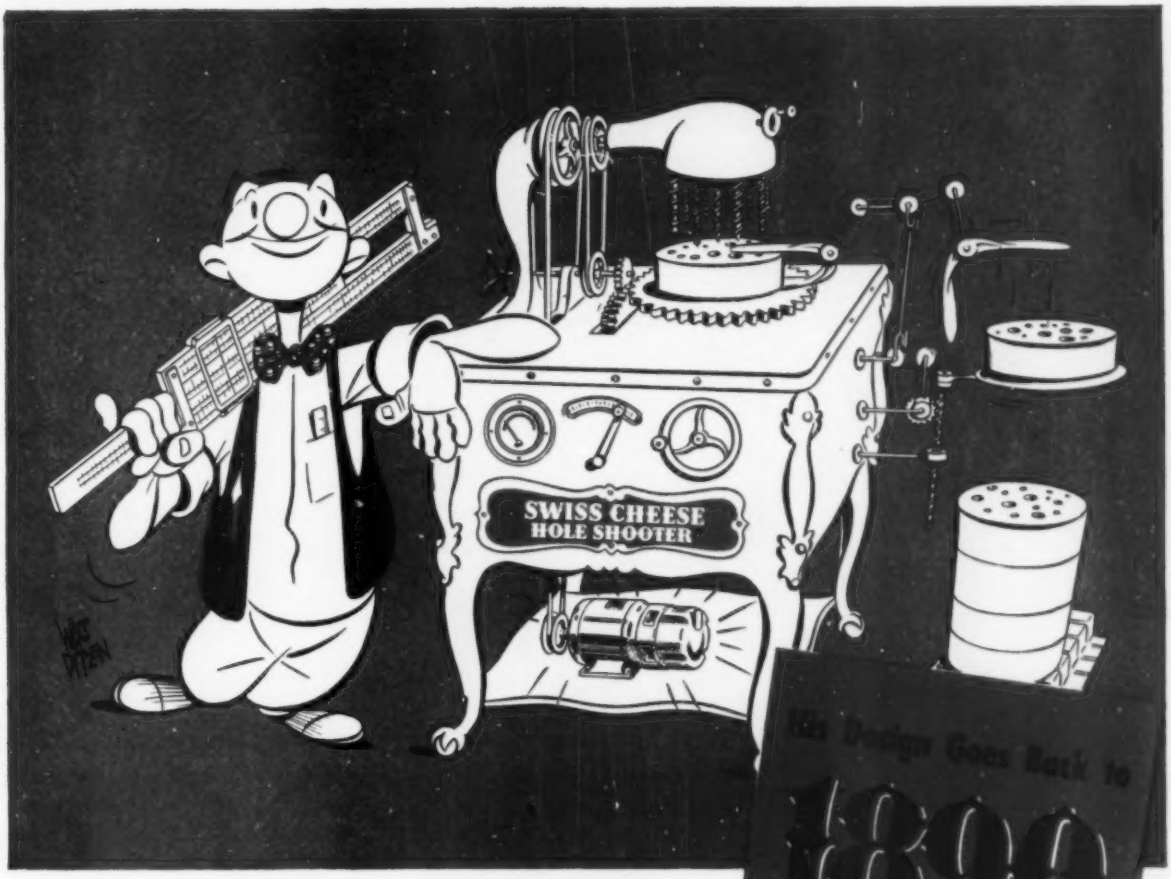
Another important feature is a comprehensive account of the meter-kilogram-second (M.K.S.) system of units. There are also new sections on the triode tube, the photocell, and a chapter on circle diagrams.

The complete contents is as follows: Chapter I—The Electric Circuit; II—Magnetism; III—Electrostatics; IV—Conduction of Electrolytics; V—Thermoelectricity; VI—The Direct Current Machine; VII—The Direct Current Dynamo; VIII—The Direct Current Motor; IX—Alternating Currents; X—Alternating Current Circuits; XI—Electrical Resunance; XII—Polyphase Working; XIII—The Static Transformer; XIV—The Alternator; XV—The Snychronous Motor and Rotary Converter; XVI—The Induction Motor; XVII—Electronics; XVIII—Illumination; XIX—Measuring Instruments; XX—Units and Dimensions; XXI—Circle Diagrams.

Standard Costs For Manufacturing

STANLEY B. HENRICI. 6 x 9 *in.* 336 *pp. Published by McGraw-Hill Book Company, Inc.,* 330 *West* 42*nd St., New York* 36, *N. Y.* $5.50.

This book begins with a brief description of the benefits of standard costs, the type of expense recording which is the foundation of the system, and a condensed view of the manner in which it works. Consideration is then given to standardization of factory operations and the establishment of standard costs, including each type of expense. The remainder of the text is devoted to discussions of how these standard costs are put to use, either as a part of, or an auxiliary to, the accounting system; and to the many spe-



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cific ways in which standard costs are used.

A great deal of the material has been revised and rewritten to bring the book completely up to date, and to provide greater clarity of presentation. Emphasis is upon a practical approach, and the text is, therefore, filled with practical examples. Especially strong in its treatment of the setting or standards, the book still offers sufficient coverage of other accounting methods.

For this second edition, additional problems have been placed at the end of many of the chapters so that the reader may apply the topics discussed in the text. Most of these are fairly simple, being designed to illustrate a single specific point in each case. Following the concluding chapters is a review problem which brings all these points together as they might occur in an actual installation of standard costs.

Automatic Control of Heating and Air Conditioning

JOHN E. HAINES, *Vice Pres., Minneapolis-Honeywell Regulator Co.,* 6 x 9 *in.,* 370 *pp. Published by McGraw-Hill Book Co.,* 330 *W.* 42*nd St., New York,* 36, *N. Y.* $6.75.

Many books have already been written about heating, ventilating and air conditioning, including helpful textbooks for beginning students. Few, if any, however, are suitable for the student interested in the automatic control of heating and air conditioning systems. This book was designed specifically with such a goal in mind.

It is not intended to be an installation and service handbook, although some practical suggestions are included and numerous typical examples of the application of controls to heating and air conditioning equipment are given. The main purpose throughout has been to explain and illustrate the basic problems of this phase of automatic control and the principles involved in solving these problems.

Included are data on measurement for purpose of control, transmitting control signals, actuating control elements, electric and pneumatic control devices, control of domestic heating, commercial heating and air conditioning, unit heaters, unit ventilators, and radiant-panel heating systems.

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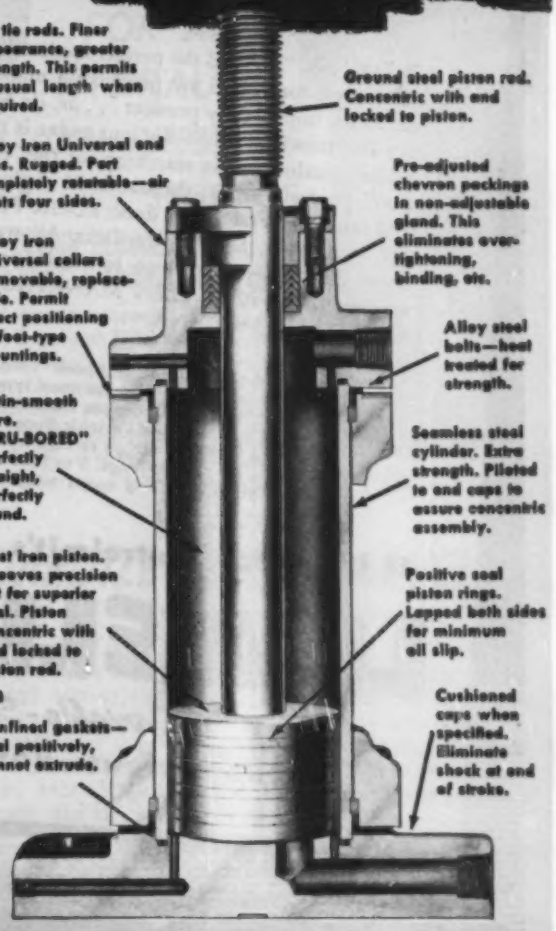
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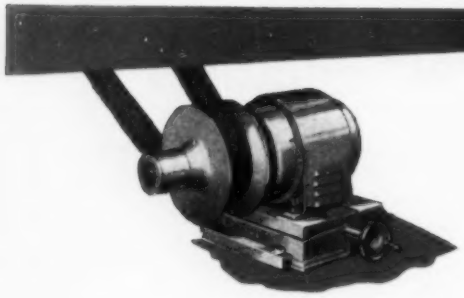

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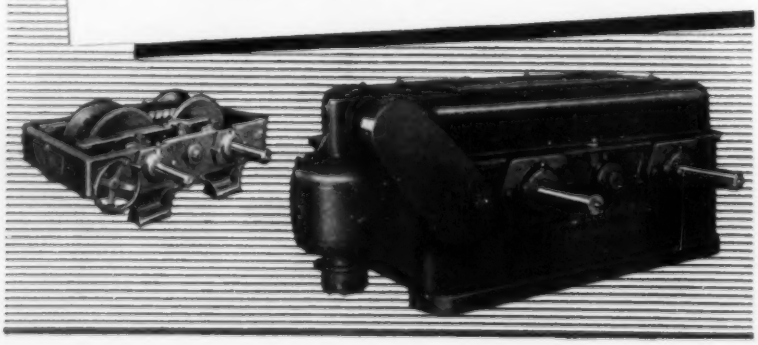


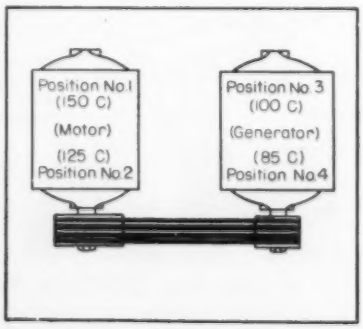
ENGINEERING ABSTRACTS

High Temperature Lubrication Of Electric Motor Ball Bearings

Abstracted from "High Temperature Lubrication of Electric Motor Ball Bearings," by J. E. Brophy, J. Larson, C. R. Singleterry and W. A. Zisman, Lubrication Branch, Chemistry Div., Naval Research Laboratory, Washington, D. C. *NLGI Spokesman*, July 1953.

THE 5-YEAR PROGRAM just completed was aimed at the development of greases and ball bearings suitable for lubricating electric motors at bearing temperatures from —40 to 150 deg C.

New or improved methods for laboratory testing of greases and for bench testing of motor ball bearings were evolved for use at 150 deg C. Nine newly developed greases (all of which are now commercially available) were investigated and tested jointly. These included a mineral oil gelled with a strontium soap, two mineral oils gelled with sodium soaps, a mineral oil diester blend gelled with lithium soap, and four silicone greases one of which was gelled with carbon black and the others with lithium soaps. Only the silicone-lithium soap greases were useful at 150 deg C for over 1,000 hr of operation without regreasing. Lowering the temperature to 125 deg C resulted in a large increase in the life of all greases tested; the silicone-soap grease having a clear advantage over all the others. However, several nonsilicone greases gave dependable operation at 125 deg C for 1,000 to 2,000 hr without regreasing. For operation at 100 deg C the three soap-gelled silicone greases and three of the nonsilicone



greases gave 10,000 to 15,000 hr of satisfactory operation without relubrication.

Each test unit consisted of two identical 440 v, 4.5 hp, Type CS, 3 phase, 60 cycle, totally enclosed, standard naval shipboard motor frames (No. 324) which housed windings with Class H (AIEE Standard) insulation. The units, shown in Fig. 1, were mounted on a bedplate and coupled by a multiple V-belt drive.

The bearings in No. 1 and No. 3 positions were No. 310, single-row, single-shield ball bearings, and in positions No. 2 and No. 4 were No. 311, single-row, single-shield ball bearings. The bearings conform to Specification 42N5. The operating temperatures for all bearings are shown on the sketch.

Each grease was tested at least twice in the "controlled" or 150 deg C bearing. The type of grease in the other bearings was changed with each failure of the particular position.

For better service simulation of motors which do not operate continuously, the test procedure was modified so that the test sets were periodically "cycled" or shut down long enough to permit the grease to cool down to room temperature.

Continuously recording the temperature of the outer races demonstrated that the type of failure occurring with greases essentially organic in nature was different from that with silicone greases. The temperature records showed that regardless of

Table I—Composition and Physical Properties of Greases

Grease	Gelling Agent Type	Gelling Agent Amount Percent	Type
A	Strontium Soap	20	Mineral Oil
B	Sodium Soap	....	Mineral Oil
C	Sodium Soap	24	Mineral Oils
D	Lithium Soap	20.6	Mineral Oil Diester Blend
E	Lithium Soap	....	Polyalkylene glycol derivative
F	Carbon Black	9	Methyl Phenyl Silicone
G	Lithium Soap	20.4	Methyl Phenyl Silicone
H	Lithium Soap	24.6	Methyl Phenyl Silicone
I	Lithium Soap	22	Methyl Phenyl

* Estimated from the measured viscosities at 100 and 210 F. by a linear extrapolation on the modified ASTM chart.

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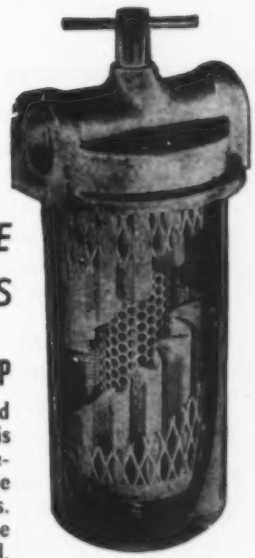

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the gelling agent used, all silicone greases exhibited the same characteristic types of failures and temperature flashes. These flashes, occurred during a large number of the silicone grease runs. They varied in frequency and, although they were occasionally accompanied by noisy operation, they sometimes occurred without noise. All tests with nonsilicone type greases were free of evidence of temperature flashes until just prior to final and decisive failures. In contrast, the temperature flashes which occurred during the silicone runs were not always an indication of imminent failure; often after the temperature flash the temperature became normal and operation was satisfactory for several hundred hours before final failure. Later reports of participating laboratories indicated these temperature flashes also occurred during their test runs.

Several uncontrollable variables operated to produce a spread of the test results:

1. Post-test examinations disclosed that the bearings which ran longest occasionally suffered a greater degree of damage because they had been run beyond the effective lubricating life of the grease. These bearings usually had broken separators and/or races which were in an advanced stage of fatigue and there were relatively large amounts of iron particles.

2. Some operators terminated runs due to a noisy condition at the beginning of a cycle in bearings which still contained grease able to continue lubrication. This noise was found to be the result of hard deposits which formed on the races during the cool period of the cycle. Other operators in the same circumstances permitted the machine to operate under these noisy conditions until the unit warmed up and the deposits either softened with the heat or were thrown from the bearings.

3. The methods used to pack the bearings with the initial charge of grease affected the life of the runs. Examinations generally showed that those bearings which contained the greatest amounts of residue in the bearing itself at the end of the run usually ran the longest.

4. The difference in temperature between the inner and outer races affected the length of the test runs. This was mostly with silicone greases.

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which lasted 4,000 hr or more generally revealed little wear on the separator. A few bearings which ran 4,000 hr experienced heavy wear which occurred late in the run. All the bearings which failed prior to 4,000 hr revealed excessive amounts of wear on the separator.

The excessive amounts of wear in the bearings which failed prematurely (as judged from the condition of the grease remaining in the bearings), was one of the factors responsible for the noisy operation reported as the criterion on which some of the runs were terminated.

Results:

There are at least three numerical performance ratings possible for each grease. They are useful for determining immediate operating procedures with motors, and for extrapolating possible long range improvements in performance of grease lubricated equipment. The numerical ratings characterize:

1. The minimum life (reached by 90 percent of the bearings tested).
2. The mean life (of all bearings lubricated with a given grease), and
3. The maximum life (as attained by the best 10 percent of the bearings lubricated with a given grease).

Item 1 bears directly on the preliminary establishment of lubrication schedules for motors operating with maximum outer race temperatures of 150 C. An examination of the average of the 20 percent of shortest runs (Table II) suggests that there is little difference between the soap-silicone greases and the petroleum greases. However, the average of the 20 per-

Table II—Life of Bearings and Greases at 150 C. (Summary)

Grease	Life (hours of operation)			Number of Runs§
	Minimum*	Mean	Maximum†	
A	202	413	850	22
B	320	1094	2487	22
C	363	798	1545	14
D	189	383	680	18
E	196	463	843	21
F	213	1328	3089	19
G	812	2710	5252	27
H	373	1850	4683	18
I	341	2799	5604	25

* Reached by 90% of greases (average of lowest 20%)
† Reached by highest 10% of greases (average of highest 20%)
§ Made with bearings stablized for operation of 170° C.

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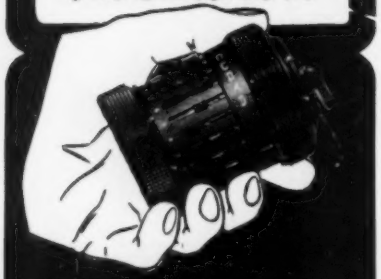

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cent of longest runs shows that a substantial number of bearings lubricated with any one of the soap-silicone greases operated for six months or longer. If a silicone grease did not fail at an early period it could be expected to have a long life. The failure of the remaining tests to run so long must be attributed chiefly to uncontrollable variations.

The petroleum greases show a concentration of test results in some specific 200 hr period, but are almost uniformly scattered through the rest of their characteristic range. The lives obtained at 150 C with soap-silicone greases, however, show no tendency to cluster at any characteristic point within the range of 400 to 6,000 hours. This absence of a characteristic life expectancy about which the test results are normally scattered may indicate that the condition of the grease present was not the controlling factor that determined the lives obtained. This conclusion is supported by the observation that soap-silicone residues in bearings which operated less than 4,000 hr did not appear, apart from contamination with magnetic wear products, to have deteriorated beyond the point where they could serve as lubricants. The need for a vigorous research attack on the control of the variables in bearing operation that are responsible for the large spread in test results at 150 C is indicated.

The soap-silicone greases indicate a longer service life in the 125 C range than do the petroleum greases. However, if the improvements in the formulation of nonsilicone greases pointed out in a later section are realized, and if modification in bearing and housing discussed can be effected, motors lubricated with suitable petroleum or ester-type greases can be operated routinely for 4,000 hr with maximum outer race temperatures of 125 C. Greases for such service, however, must be given adequate functional testing before acceptance. Very wide differences in life at 125 C may be expected from the various greases now qualified under specification AN-G-5a.

Not enough data were reported on the performance of the program greases at 100 and 80 C to permit significant estimates of the life that may be expected with each lubricant at these lower temperatures. Pre-

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liminary data reported by the Engineering Experiment Station in October 1949 indicate clearly that at 90C to 100 C a life of 15,000 hr without relubrication may be obtained with several soap-petroleum high-temperature greases, as well as with all three of the silicone greases studied.

Seizing in Metal Wear

Abstracted from "Mechanical Aspect of Seizing in Metal Wear" by Harry Czyzewski, a paper presented at the ASME 1953, Semi-Annual Meeting.

THE PURPOSE OF THIS PAPER is to present the mechanical aspect of seizing in metal wear that accounts for the observed phenomena in accelerated mechanical abrasion. The mechanical analysis also explains the failure of externally lubricated alloys to equal the performance of self-lubricated alloys.

When a particle abrades a surface, a definite relationship exists between the dimensions of the abrading particle and the track or furrow left on the abraded surface. The mechanical abrasion may be classified as: (A) Normal; or (B) Accelerated.

In normal mechanical abrasion, the track left by the abrader, except for elastic recovery, has a profile the same as the profile of the contacting part of the abrader. There is little difference in response to normal mechanical abrasion between self-lubricated and externally lubricated alloys.

In accelerated mechanical abrasion, the track left by the abrader has a larger profile than the profile of the contacting part of the abrader.

For the purpose of this paper, the author defines "seizing" as the state in which the relative motion of the opposing metal parts is stopped, because the track increases in profile to the extent that further propagation of the track requires more translational energy than is available in the system. "Galling" may be defined as arrested seizing; that is, the increased track profile becomes constant or decreases with continued propagation of the track.

Self-lubricated alloys vary markedly from externally lubricated alloys. Self-lubricated alloys have less tendency to seize and suffer less damage when galling does take place. This superiority is generally attributed to lubrication.

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Most efforts by external lubrication, however, fail to duplicate the resistance of the self-lubricated alloys to the incipience of galling. Especially, the decreased damage from galling.

When seizing is initiated in metal-to-metal wear, it is evident that a change has occurred from normal to accelerated mechanical abrasion. In this paper, the author presents a method of analyzing this change qualitatively in terms of stress distribution at the point of contact.

The adoption of the mechanical interpretation of accelerated mechanical abrasion would provide a principle upon which to design surfaces of "engineered roughness." Many instances of the significance of such engineered roughness are known in practice.

The importance of graphite-flake size, shape and distribution in gray cast-iron application is well known. From the standpoint of self-lubrication, the dimensions of the "lubricant reservoir" would not be too critical. In practice, the graphite-flake classification is controlled closely for such parts as piston rings, cylinders and other wearing-surface applications.

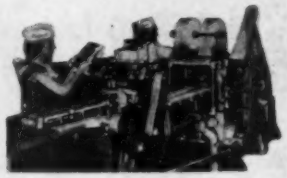
For proper wearing-in of many metal parts, it is necessary to have good resistance to accelerated mechanical abrasion. In most industrial applications, the mechanical effect is complementary to the lubrication-film effect of separating the surfaces, but somewhat decreases the importance accorded to the lubrication effect alone.

Hydraulic Fuses

Abstracted from "Hydraulic Fuses . . . What Are They? How Do They Work?" by Harry Hedland, Director of Engineering, Waterman Engineering Company, *Applied Hydraulics*, June 1953.

HYDRAULIC FUSES are devices that act automatically to protect main power supply lines or sub-systems in hydraulic circuits against leaks or failures. Fuses may be used to isolate ruptured circuits; they offer the maximum protection against fire hazards and complete loss of fluids in hydraulic systems.

Of the many types of hydraulic fuses, two have been accepted to the extent that the services have issued standard drawings to cover them. Required to conform, performance-wise, to specification MIL-F-5508, these two



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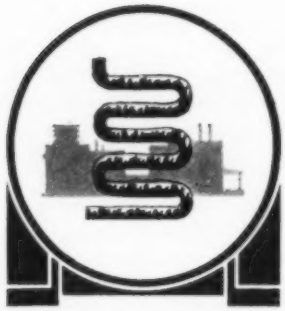

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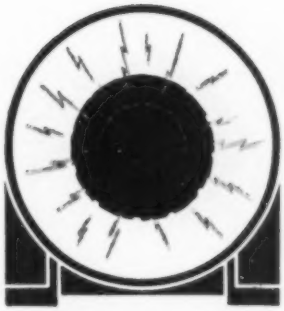

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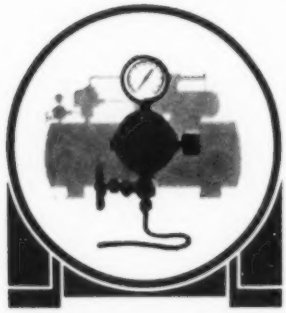

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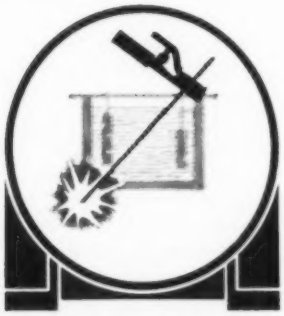

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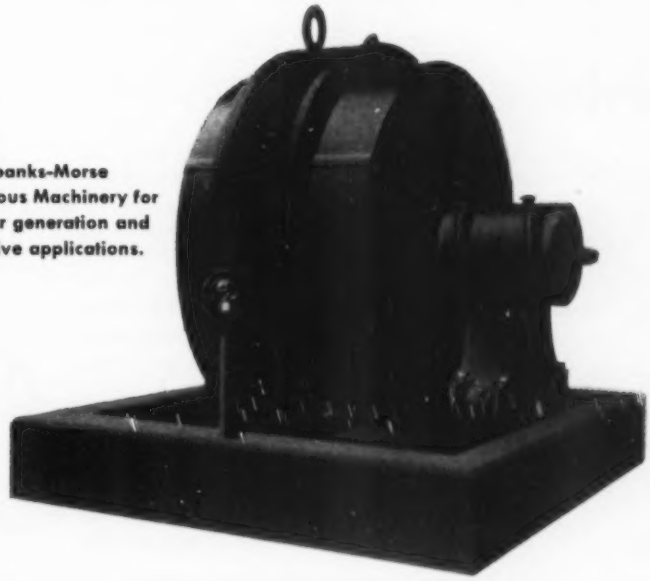

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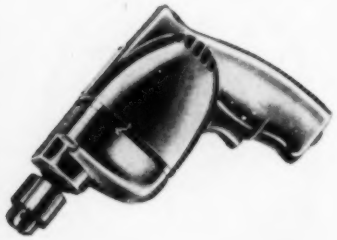

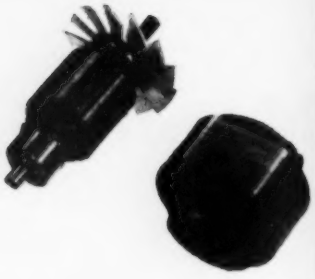

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the "Quantity Measuring" type and differ in the means of resetting. The quantity measuring fuse is a device to measure the volume of a fluid. It acts as a delayed action check valve—passing the amount or volume of fluid required to perform a given operation, but closing if the subsystem demands more than a normal quality of fluid due to leaks or a ruptured tube. In normal operation, however, with the fuse calibrated for slightly more volume than the working capacity of the subsystem which it serves, the fuse will never close. The signal for this type of fuse to close is an above normal volume of flow. This type of fuse can be, and is, successfully applied to circuits involving fixed displacement actuating cylinders or fluid motors of limited motion. These fuses operate at flow rates of from one-tenth gpm up to, and occasionally, exceeding 12 gpm. Fig. 1 shows typical volumetric capacity vs flow rate curves for various standard capacities under various conditions.

The type 1 hydraulic fuse or AN 6281 is designed to reset itself by an internal spring mechanism, provided the capacity of the fuse has not been passed or whenever the pressure on the two ports is equal. This type will remain open unless an above normal volume of flow passes through it.

The type 2 hydraulic fuse or AN 6282 is designed to lock itself in a partially fused position when flow ceases and to remain locked in that position until flow is resumed. The advent of reverse flow will reset the fuse.

An advantage of the type 2 design is that when used in a circuit where a partial cycle is made, the volumetric capacity of the fuse is reduced. Such

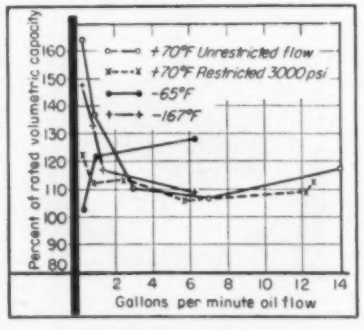

Fig. 1—Typical volumetric capacity vs flow rate curves for various standard capacities under various conditions.

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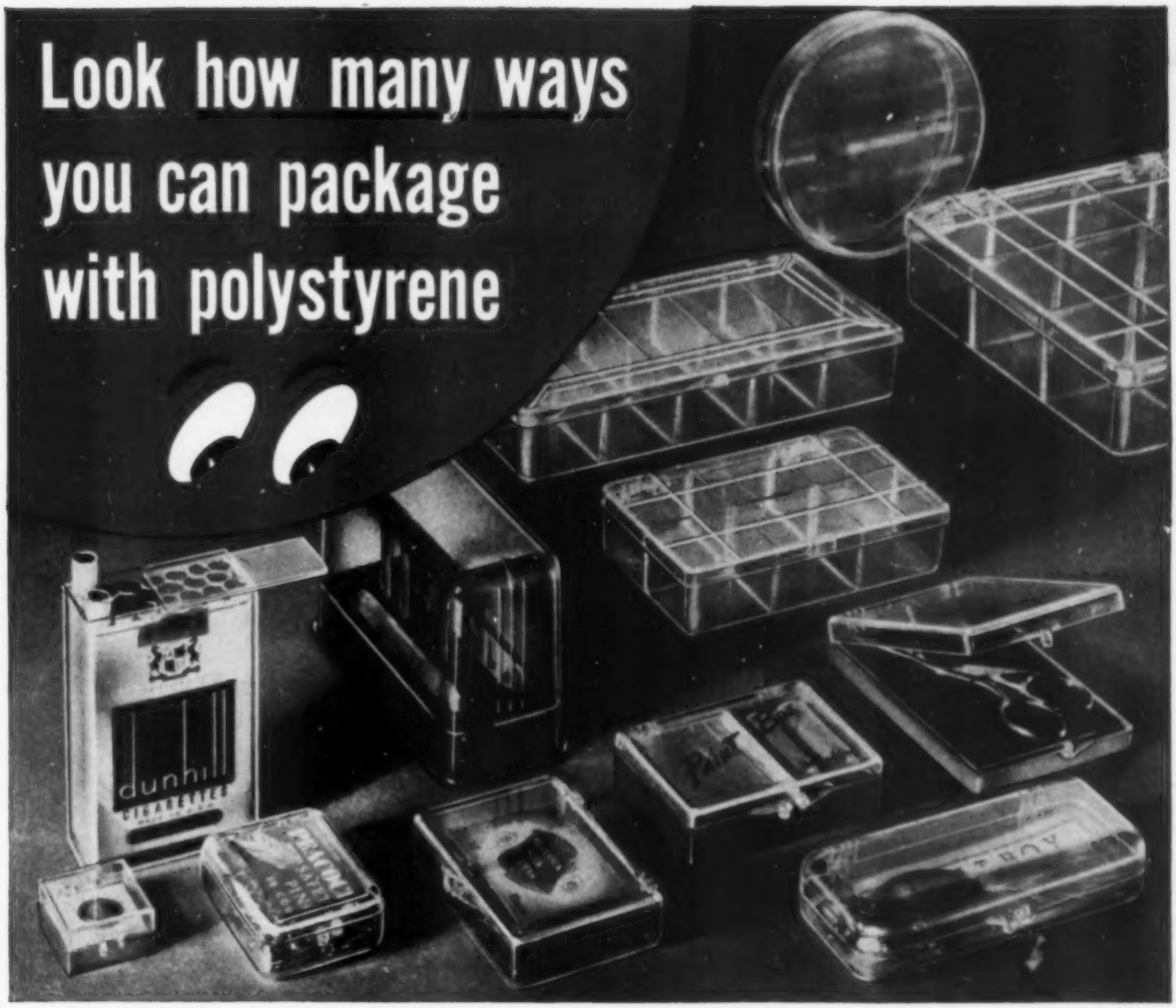

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action is of particular value when the fuse is used in conjunction with a large volume cylinder that might be extended over long periods of time with pressure maintained. Because the cylinder is extended, the fuse capacity has been nearly passed, and the line is vulnerable because it contains fluid under pressure. However, if such a line is ruptured, only a few cubic inches of fluid will be lost before the line is isolated by the fuse.

Either the type 1 or type 2 quantity measuring fuse can be utilized effectively as a fire prevention device. A typical example of such application would be on an aircraft cowl flap cylinder where flexible hose is used. Should the hose fail, as it does often, the fuse would limit to a minimum the amount of fluid that is sprayed into the engine compartment.

Components Department Aids Project Engineers

Abstracted from "Components Department Aids Project Engineers" by S. Kramer and S. Gurian, Radio Receptor Co. *Electronics*, August, 1953, p. 141.

INCREASING DEMAND by the government upon civilian contractors and industry to produce government material and equipment has brought about a new problem, that of government-contract administration. The government requires and demands stringent adherence to the many diverse specifications under which the contract is awarded.

Specifications Problem

Under the project-engineer system, the project engineer, being responsible for the entire job, is faced with an insurmountable load of specifications to which he must adhere. Not only must his design meet specifications in operation, but the components and parts that go into the final manufacture of the overall equipment must also conform to their individual specifications. As a result, a great many man-hours that would normally be devoted to design work by the project engineer are spent delving into specifications, interpreting them and carrying on correspondence with the government agencies concerned for waivers and deviation approvals.

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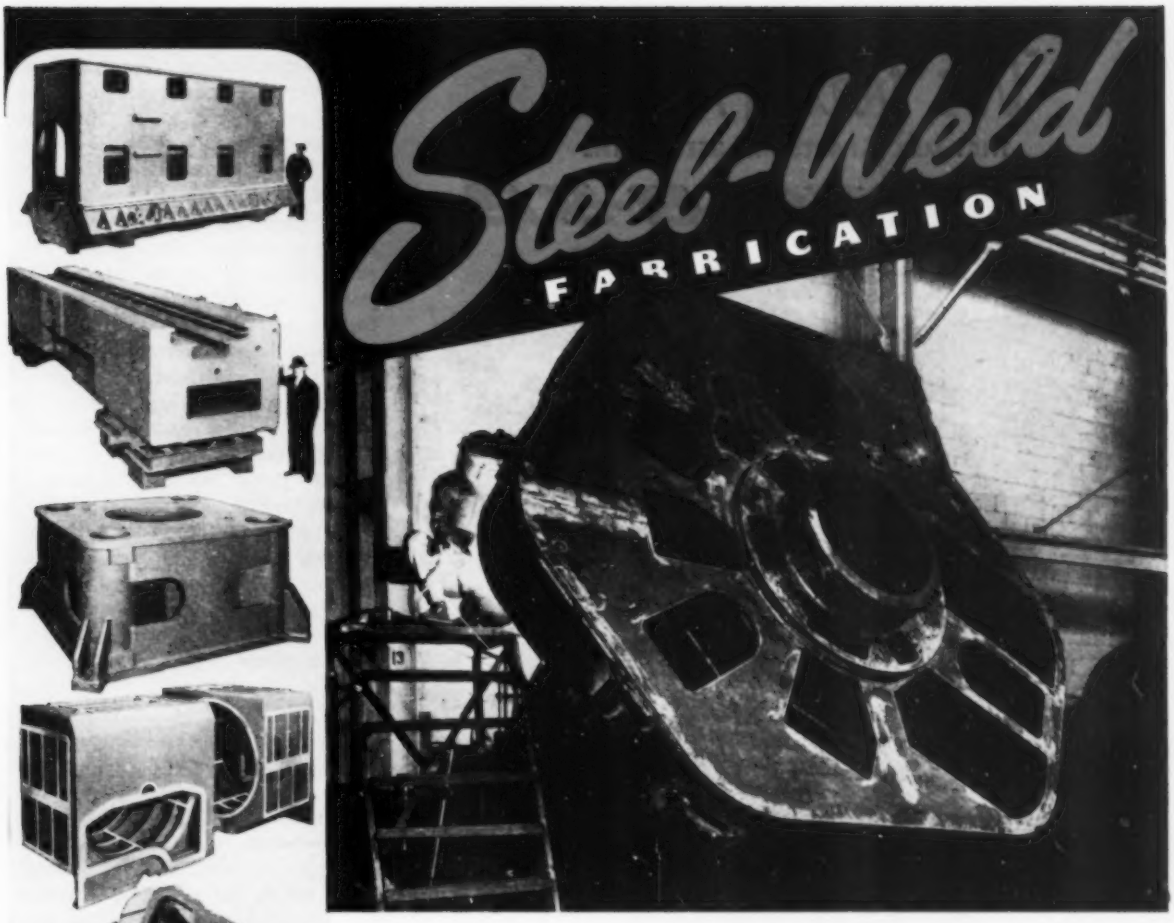

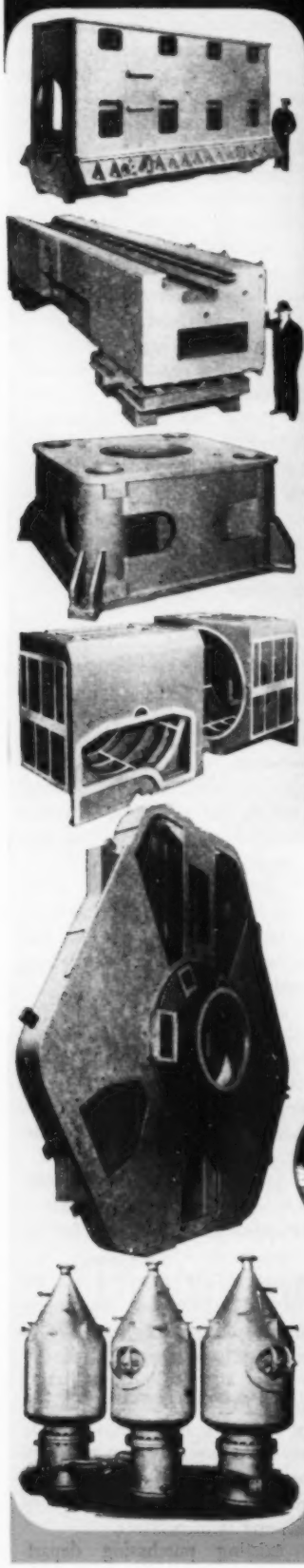

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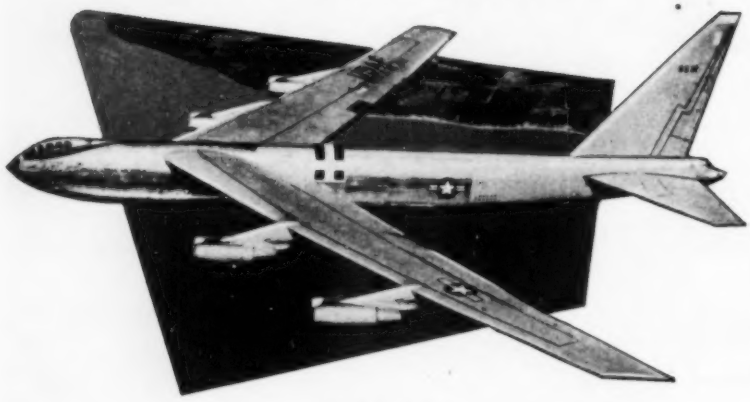

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with all specifications other than those directly related to the design of the equipment, at least one-half more of his time can be put into actual design.

Responsibility for meeting the other specifications is turned over to a group designated with the sole responsibility of contract administration. Its prime functions are to provide the project engineer with sufficient information about the specifications on his particular contract and to handle all of the administrative and engineering functions other than those strictly concerned with design. This includes contract analysis, approval of component parts, waivers, deviations, descriptive patterns, drawing specifications and supplying a flow of components, materials and processes acceptable to the government agency concerned for use in this end equipment. This group is called the components group.

Organization of Group

The chief components engineer is responsible for the function of the entire group. He also serves as the liaison man for dealing directly with representatives of the government agencies concerned, and is the final review point for all parts, materials and processes employed in this particular project.

The contract administrator is responsible for analyzing the contract, picking out all the specifications that are part of the contract, and collecting all subsidiary specifications.

The specifications engineer is responsible for completing component drawings so that the specifications include all of the government standards for finishing, material, processes, workmanship, marking and other details.

The prime responsiblity of the standards engineer is to maintain a flow of approved components for use in the equipment.

Test results are recorded in the form of an engineering sample report that is ultimately transmitted to the procurement department.

The parts analyst heads a section responsible for the complete descriptions of the component parts used in the overall equipment, along with preparation of parts lists, preferred lists for procurement, processes, bills of materials and nomenclature.

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ment retains all of its normal functions, except that it is limited to procuring components that have individually been tested and approved by the components group.

Comparison of Systems

Where the project engineer is in direct relationship with the government engineers, one project may get approval for a particular component while the project for another agency is denied such approval. This means that the production line must segregate its output for individual waivers, necessitating individual stock control systems, individual procurement and parallel assembly facilities. The new components-department system eliminates this.

In the project-engineer system, when a particular component is required to fit design needs, the project engineer must investigate the ability of the component manufacturer to produce this component according to government specifications, and must gain approval of the component by the government agency for which his project was designed. Under the components-group setup, these problems are relayed instead to the standards engineer. He maintains a catalog of acceptable components for use on military equipment.

The specifications engineer is able to provide a certain amount of uniformity throughout the organization in the choice of components by establishing so-called preferred lists of acceptable components. In addition, he raises the general level of standards for the entire organization by devoting a good part of his time to weeding out those components that are generally inferior to present engineering practices.

The specifications engineer also supplies uniform manufacturing drawings that can be used by all project engineers at the same time. Usually one drawing takes the place of twelve or more individual drawings and satisfies the requirements of all projects simultaneously.

The parts section provides the same type of saving of time and energy in the sense that a description for a part is written once. It is necessary only, in order to bring out a tabular list of parts, to review part descriptions, collate the masters and run off a set to make a new tabular list of parts.

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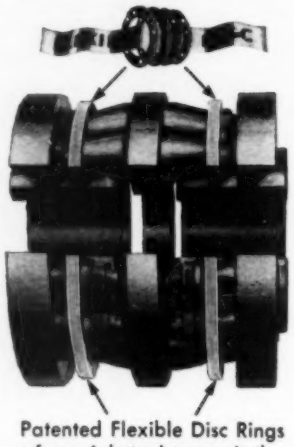

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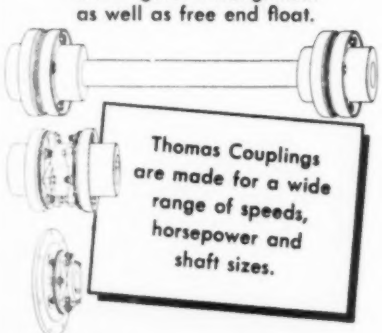

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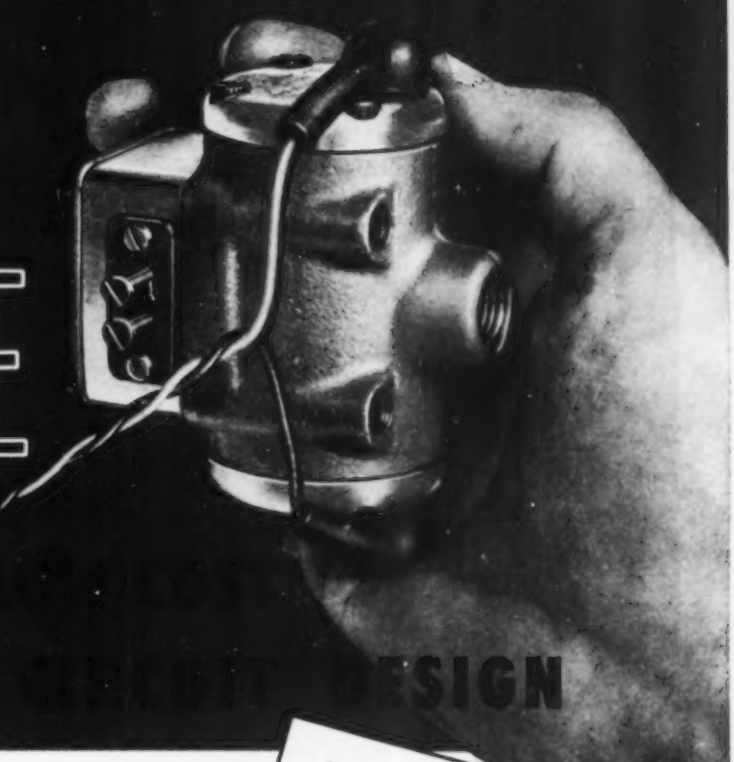

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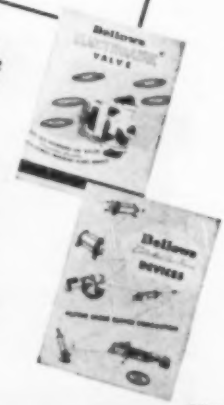

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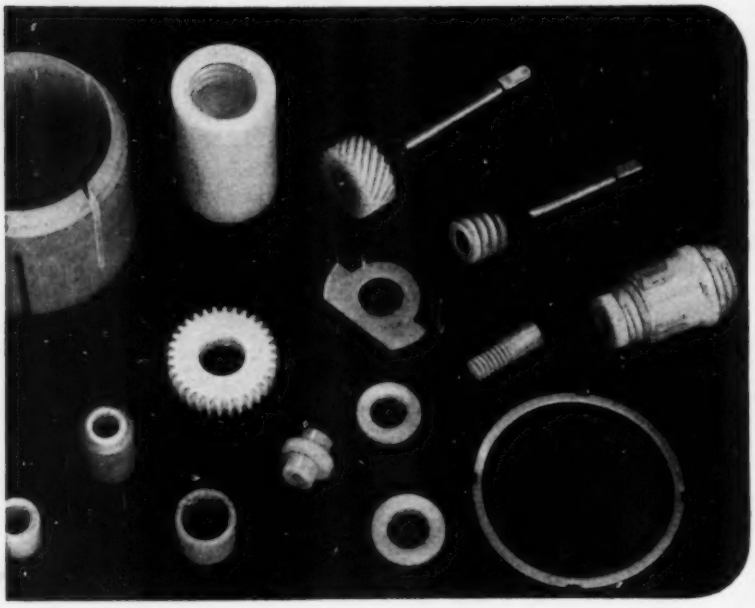

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For Measurement and Control

This 28-page Special Editorial Report from our November 1952 issue will give you the most up-to-date details on strain gages and this design tool's great versatility.

The first of five sections in this special report covers the two classes of gage—bonded and unbonded, types of bridge circuit, amplifying and recording equipment and the systems combining these components. The four remaining sections take up the different types of transducers designed specifically for measuring pressure, flow, weight and displacement. Case histories follow each transducer section to illustrate some of the more unusual applications for strain gage transducers.

Copies available at 35 cents each.

READER SERVICE DEPARTMENT

Product Engineering

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New York 36, N. Y.

STAINLESS STEEL KITCHENWARE

McLouth STAINLESS Steel

For the product you make today and the product you plan for tomorrow.

McLouth Steel Corporation
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Manufacturers of Stainless and Carbon Steels

Here's how MMM molds "MULTIPLASTICS PARTS" for One-Source-Service in Production Manufacturing

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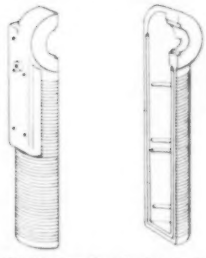
MMMolded Phenolic Back & Bottom

MMMolded Polystyrene Cover and Acrylic Viewing Lens

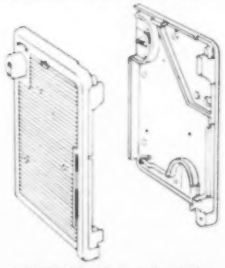
MMMolded High Impact Polystyrene Film Cage

MMMolded Acrylic Sighting Lens and Butyrate Lens Mount



MMMolded Phenolic Flash Gun Housing

MMMolded Butyrate Taking Lens Mount



MMMolded Phenolic Sides

(11) MMM Customolded Camera Components...

MMM molders and mold makers are long on experience in producing custom parts to meet the requirements of fast precise production line assembling. And continuous research with new materials and new techniques qualifies MMMolders to produce the part to fit the function. From the plastic lenses to the plastic housing this 11 piece production is an example of how it's done. Let us do it for you. What's your production problem?

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Midwest Molding AND **Manufacturing** COMPANY
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We are interested in: Custom Plastics ☐ Electronic Parts ☐ Molded Motor Parts ☐

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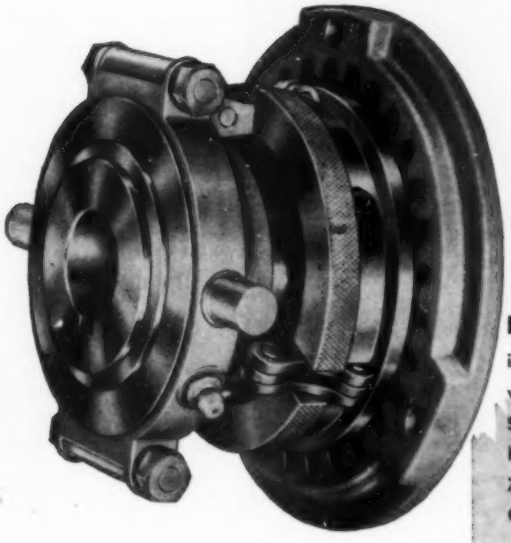
Check JOHNSON single disc a Better CLUTCH for the same money



Better BECAUSE . . . it's the only clutch with SEPARATOR SPRINGS that prevent heating in both HORIZONTAL and VERTICAL installations.

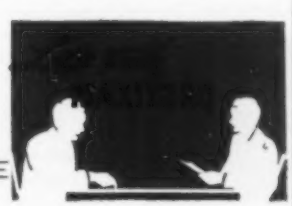
For some time there has been a demand for a single disc clutch for positive control of power transmission in the field of light machinery . . . a clutch that would stay cool on the job in both horizontal and vertical installations. This is "it."

If extreme compactness is not an essential, the Johnson No. 350 (3 h.p. max.) and No. 450 (6 h.p. max.) will meet or beat competition . . . as a better clutch at a competitive price. They incorporate most of the design principles of our Maxitorq multiple disc . . . and except for compactness and capacity, you will find them tops in their field. (Please read column at right . . . "Frankly Speaking" . . . for use recommendations.)

Several driving combinations are available, including V-belt. A simple hex key frees the knurled ring for easy manual adjustment. The "floating" disc prevents drag, abrasion, and heating in neutral. Machine and product designers will solve many problems in the light machinery field with this new Johnson single disc Clutch.

Send for Bulletin No. 250-PE-9

THE CARLYLE JOHNSON MACHINE CO.
MANCHESTER . . . . . CONNECTICUT



EC/SS

Frankly SPEAKING

Because of a large backlog of orders, The Carlyle Johnson Machine Company found it necessary to postpone the announcement of the new Johnson Single Disc Clutches.

Now, with added equipment for high speed production, it is possible to produce and ship the new clutches without undue delay. In fact, small orders or units for try-out in new machines will be forwarded at once. Design features make the Johnson especially suitable for installation in the following machinery:

Accessory Drives, Air Compressors, Bag Making, Boat Drives, Bread Wrapping, Chain Drives, Combines (farm), Conveyors, Crop Seeders, Cultivators, Dusting Machines, Feed Grinders, Floor Scrubbing, Fruit Cleaners, Gasoline Engines, Generator Drives, Hay Balers, Hoists, Loaders, Lawn Mowers, Milk Coolers, Mixing Machines, Motor Scooters, Packaging Machines, Paper Shredders, Power Fans, Power Saws, Power Take-offs, Pumping Equipment, Sand Spreaders, Sewing Machines, Sheep Shearers, Spraying Equipment, Textile Machinery, Threshers (small), Tobacco Machinery, Tool Grinders, Tractors (garden), V-Belt Drives, Vegetable Sorters.

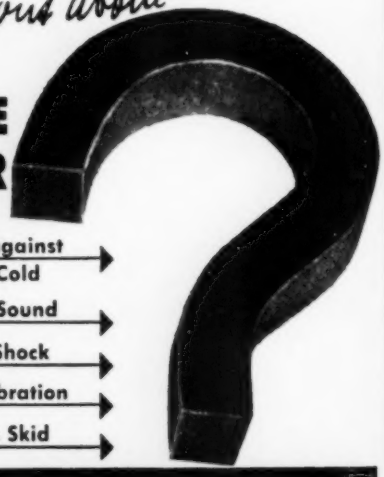
Naturally, these are but a few of the possible app'ications for the Johnson Single Disc Clutch. The field is wide open, with new machinery constantly being developed.

Included in the driving combinations are: Gear Tooth, Bolted Plate, Pulley Type, Hub Adapter, Cut-off Coupling Adapter, Single V-Belt Pulley Drive, and Double V-Belt Pulley Drive.

Carlyle Johnson engineers offer their engineering assistance in cooperation with your engineers and machine designers to develop the correct solution of your power transmission requirements. Write to Frank R. Simon, The Carlyle Johnson Machine Co., Manchester, Conn.

Here are answers to questions about

SPONGE RUBBER



- Insulates against Heat or Cold
- Dampens Sound
- Absorbs Shock
- Controls Vibration
- Prevents Skid

DUTCH BRAND Sponge Rubber

AIDS IN SOLVING MANY MANUFACTURING PROBLEMS

Meets ASTM Specifications. Available in Four Densities . . . Five Colors . . . in rolls, sheets, strips with or without adhesive . . . die cut forms.

DUTCH BRAND Sponge Rubber is carefully manufactured and is fresh, live and of top quality. Available in rolls, sheets, strips or in special die cut forms or custom molded pieces to meet manufacturing needs. The availability of five colors is a big assist in working out product appearance. Because of its characteristics it serves many purposes in product manufacturing. Being available coated with adhesive or without simplifies production in many cases.

If you are now using sponge rubber in conjunction with manufacturing or are thinking of doing so, it will pay you to have full information on DUTCH BRAND Sponge Rubber.

DENSITIES

Natural Rubber	ASTM Specifications No. D1056-51T
No. 3832 Soft Density	RN11
No. 4022 Medium density	RN12
No. 4030 Firm Density	RN13
No. 4031 Hard Density	RN14
Neoprene	
No. 3399 Soft Density	SC11
No. 3394 Medium Density	SC14

COLORS

1. Brown 2. Gray 3. Red 4. Green 5. Black
Other colors available where quantities warrant

THICKNESSES

⅛ inch to 1 inch inclusive

Here are a Few of the Many Uses for Sponge Rubber Today!

- Cushion vibration
- Prevent squeaking and wear
- Dampen sound
- Absorb shock
- Seal joints
- Make gaskets
- Mount delicate instruments
- Prevent skid
- Set glass in metal frame
- Insulate against heat or cold
- Prevent metal to metal contact
- Protect against scratch or abrasion
- Weatherstrip metal sash
- Prevent friction
- Prevent leaks
- Other specification requirements

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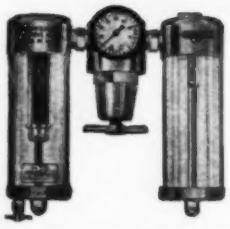
"M-B" Automatic Air Line FILTER, REGULATOR and LUBRICATOR Assembly



The value of "M-B" Automatic Air Line Filters, Regulators and Lubricators is widely known for their effectiveness as a protection to Air Valves, Cylinders, Pneumatic Tools, etc.

"Your 'Sentinel of the Air Line' has been giving us very good service. We have had no complaints at all and I trust that we will be ordering more of them in the near future."

signed: **A. E. Cranston, Sr.**
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Now— ALUMINUM SOLDERING MADE EASY!

A Universal Flux For All Commercial Metals Usually Joined By Soldering

SX PRODUCTS

Aluma-Flux SOLDERING FLUX

Manufactured By
ESSEX WIRE CORP.
Ft. Wayne, Ind.

Here at last is the only flux ever developed that makes possible the *non-corrosive* joining of all types of aluminum alloys by any soldering method—manual, dip or mechanical. No cleaning is required after soldering is accomplished—Aluma-Flux leaves no corrosive residue—soldered pieces are ready for use immediately.

S-X Aluma-Flux is equally effective for soldering stainless steel, bare and galvanized carbon steel, cast iron and other ferrous alloys, copper, brass and nickel—all commerical metals commonly joined by soldering. The joining of aluminum to brass; the coating of copper with tin; and the soldering of other unlike metals is made fast and easy with Aluma-Flux.

Soldered joints in aluminum produce no corrosive action due to flux residue when exposed to salt-spray, high humidity, alkaline water, etc. Aluma-Flux shows no detrimental effect on any soldered joint.

S-X Aluma-Flux can be used with 100% satisfactory results in powdered form as delivered, or in molten form—whichever is most efficient for the job. Virtually any type of solder can be used. Aluma-Flux can be stored indefinitely without change of weight, or any impairment of fluxing efficiency. Being non-hygroscopic, it will not absorb water.

In addition to its exceptional fluxing characteristics, Aluma-Flux offers many other cost-reducing, time-saving advantages . . .

The success of S-X Aluma-Flux in the soldering of aluminum is due to the action in which the flux initially reduces surface oxides and then immediately deposits a thin layer of plating material on the solder area. Oxidation of the area to be soldered is thus prevented while the plating material serves as an approved base on which to solder. In addition to its soldering efficiency, Aluma-Flux reacts completely during the joining operation so there are no corrosive flux residues to lower corrosion resistance of the finished joint.

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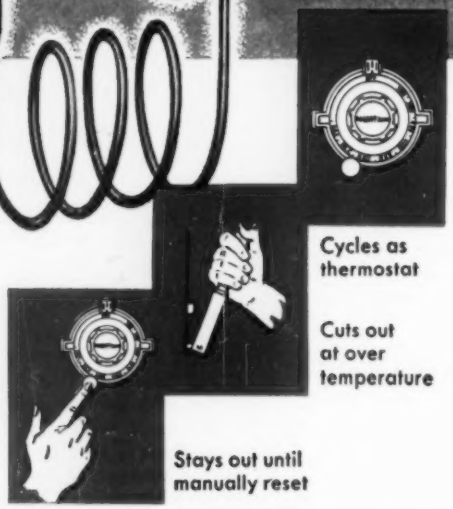

Combines temperature control with single pole switch. Current is automatically cut off and switch is locked in open position if temperature at any dial setting, through any cause, exceeds temperature range of control by approximately 7% in liquids or 12% in air. Switch remains open until closed by manual reset button. Design permits mounting control in any one of four positions. Standard size bulbs and capillary tube lengths give great flexibility to meet required heat ranges and installation needs. In direct or reverse acting models. *Write for Catalog.*

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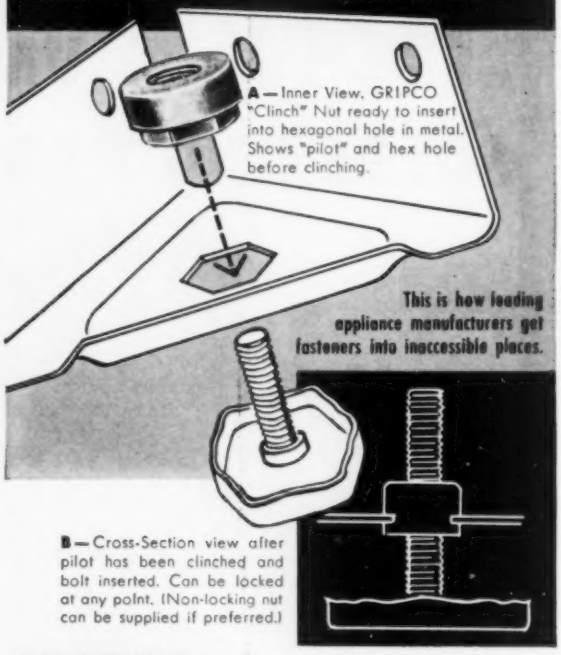
ANY "BLIND" ASSEMBLIES?



A—Inner View. GRIPCO "Clinch" Nut ready to insert into hexagonal hole in metal. Shows "pilot" and hex hole before clinching.

This is how leading appliance manufacturers get fasteners into inaccessible places.

B—Cross-Section view after pilot has been clinched and bolt inserted. Can be locked at any point. (Non-locking nut can be supplied if preferred.)

GRIPCO CLINCH NUTS

The above typical application shows how GRIPCO "Clinch" Nuts are successfully used by famous makers of ranges and other appliances such as washers, dryers, refrigerators, freezers, room air conditioners, etc. In the example illustrated the GRIPCO "Clinch" Nuts serve a dual purpose; first, for crating, holding the product rigid in its container during shipment, with no possibility of bolts "backing out" and allowing the appliance to become damaged while shipping; and second, after installation, for holding the bolts which serve as feet that are adjustable for levelling.

Do you have any application on which fastening must be made from a hard-to-get-at point; or do you need additional threading depth for applying bolts to thin metals? Investigate this method of firmly affixing GRIPCO "Clinch" Nut to the work so it is already in position when bolt is applied.

Where Welding is Available — You may prefer to use

GRIPCO Pilot Projection Weld Nuts Circular pilot accurately positions nut in the bolt hole, for resistance welding. No jigs necessary. Two pilot heights for different gages of metal.

or GRIPCO Countersink Weld Nuts The special countersink feature eliminates the possibility of hot metal particles lodging in the threads; thus no retapping is necessary.

6-POINT SECURITY AGAINST FASTENER FAILURE

GRIPCO LOCK NUTS

1—Firmly lock on to bolt at any position.
2—"Stay put" on bolt, in spite of vibration, tension, etc.
3—Positive locking action not due to any outside devices, but result of simple vertical thread deflection.
4—Oil or water do not affect Gripco locking action.
5—Can be removed with a wrench and reapplied repeatedly without loss of locking action.
6—Cost less because of simple design.

Write for samples, mentioning types and sizes of nuts you use. 357

GRIPCO **GRIP NUT COMPANY**

308-J S. Michigan Ave., Chicago 4, Ill.

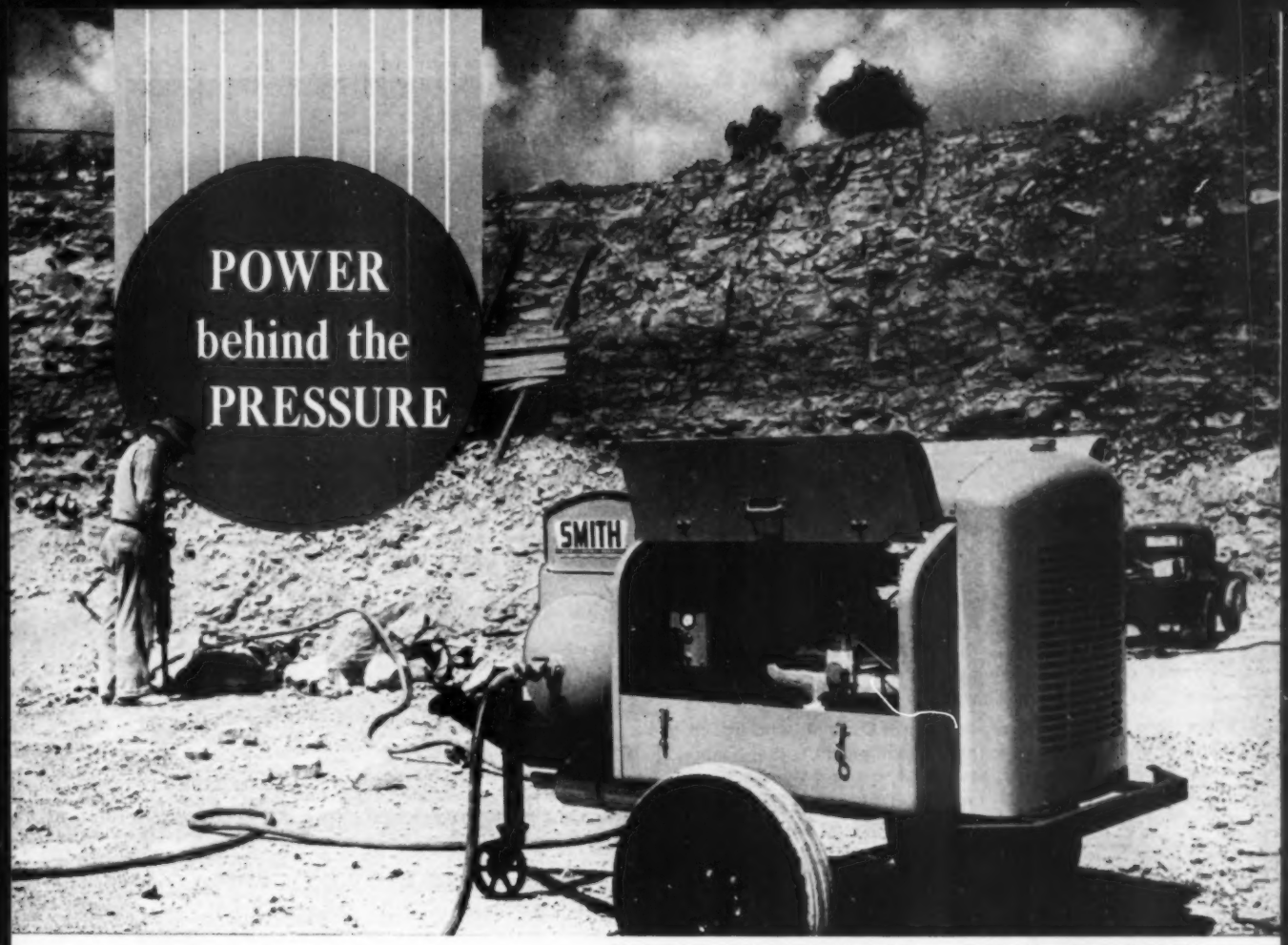
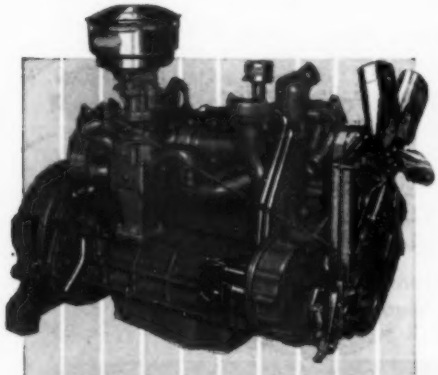


Photo courtesy Gordon Smith and Company, Bowling Green, Kentucky

air...120 cubic feet per minute...with Chrysler–modern industrial power



Here's Pedigreed Horsepower in another role . . . this time it's the Chrysler Industrial Model 22 Engine whose 413 cubic inches displacement is powering an air compressor. The air compressor, in turn, is operating a rock drill with which holes are being prepared for blasting. Fifty-five pound rock drills, two eighty pound paving breakers, two eighty pound sheeting drivers, four backfill tampers, two concrete vibrators . . . they're all "duck soup" to this Air Compressor.

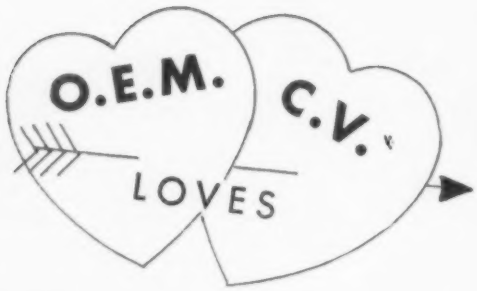
The outstanding power to weight ratios of Chrysler Industrial Engines make them ideal power plants for light, compact, portable equipment like this Gordon Smith Air Compressor. The total weight of this entire unit is below the weight of the power plant alone in some air compressors.

Greater power per pound weight, longer service with less maintenance . . . these are important advantages of Chrysler Industrial Power. Another is your ability to select Chrysler Engines equipped to your needs *without* substantial increase in the unit costs of engines. That's because Chrysler production-line methods adapted to specialized industrial engine building, provide custom-built engines at mass-production prices.

Chrysler Industrial Engine sales and service facilities are nationwide. Let the nearest dealer show you what Chrysler Power can do for you, or write: ***Dept. 49, Industrial Engine Division, Chrysler Corporation, Trenton, Michigan.***

CHRYSLER
Industrial Engines

HORSEPOWER WITH A PEDIGREE



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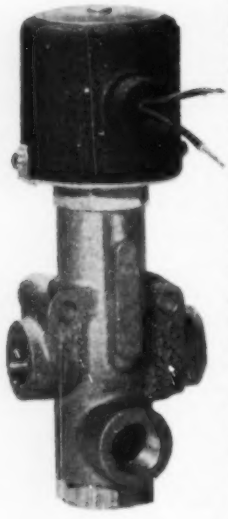
Original Equipment Manufacturers who have been steady Crescent Valve users include many leading companies in their respective fields.

For many years now, Crescent Valves have been designed into cement batching equipment, spot welders, industrial weighing equipment, hopper control for chemical plants, conveyors and work feed equipment, pilot control of large diaphragm operated valves, riveting machines, and many others.

Crescent Valves were **made for the O. E. M.** who has to design millions of cycles into his equipment without service worries from valve trouble or solenoid burn-out.



The production minded O. E. M. will recognize, at a glance, that Crescent Valves are designed for volume production; that's why the price is low and the delivery prompt.

The sales minded O. E. M. will appreciate the extreme flexibility of Crescent Valves. They can be converted to practically any AC or DC voltage by simply changing coils. Sales and service are handled by a national organization represented in every major trading area by competent field engineers.

*Crescent Solenoid Operated, Pilot Controlled, 3-Way and 4-Way Valves for air, water, and light oil service. Sizes 1/4", 3/8", 1/2", and 3/4". Pressures to 500 P. S. I.

Write for Catalog 3C-1.

model 1034 3-way valve

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- Rugged • No Rattle
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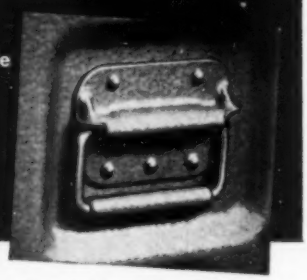

Attention manufacturers of portable equipment, carrying cases, parts boxes, etc.! If your product requires side-carry handles, install the best—the Bendix-Friez handle. This superior handle was developed to meet strict military requirements for many specialized equipment uses. Ruggedly built of aluminum and stainless steel in a sturdy design, it knows no equal for long, faithful service. Can be riveted or welded to any kind of container . . . or depressed in the surface, if desired. Unique "snap-back" feature stops rattle from shock and vibration. Prompt attention to both large and small lot orders. Try us today.

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AGAIN!

Reo Motors, Lansing, Mich., have again specified STRESSPROOF—this time for the power shaft on their new rotary lawn mower.

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Reo Lawn Mower
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Reo engineers needed *top performance* from this new drive shaft . . . so they insisted on STRESSPROOF! They knew from years of successful experience with STRESSPROOF that it could take abuse. It had both the strength and wearability to stand up under the toughest service—and its excellent machinability was most welcome from a cost standpoint.

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Only STRESSPROOF gives you a unique combination of four qualities *in-the-bar:* Strength, Wearability, Machinability, and Minimum Warpage. Yet it costs less than the other quality cold-finished steel bars.

STRESSPROOF makes a better part at lower cost! It is available in cold-drawn or ground and polished finish.

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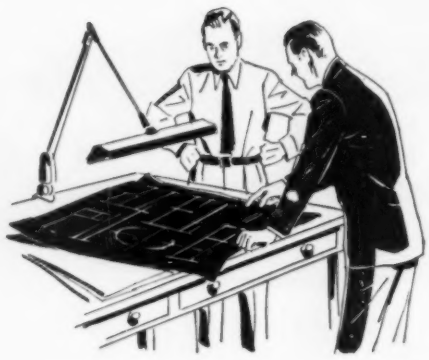

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Zenith's skill and experience have always been concentrated to one particular end—to provide the finest in specialized carburetion. Through the years Zenith has dealt with every type of engine—ranging from single cylinder lightweights to the most rugged and powerful of gasoline engines—applying 25 years of experience to the mastery of almost every conceivable carburetor problem. In engineering the individual carburetor to the specific requirements of the job, questions of placement, efficiency of performance, and economy of operation are considered from blueprint to production stage. If you are looking for the answer to a particular carburetion problem, you are looking for Zenith. Inquiries will receive prompt attention.

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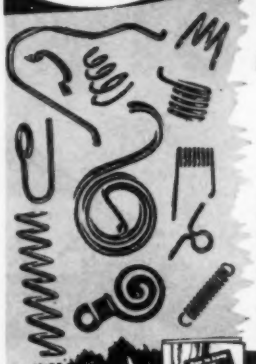

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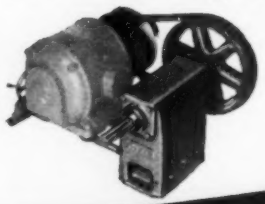

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SPEED PULLEYS

A mere turn of the hand is all that is required for instant speed correction on your machinery. Changes in production schedules, operator speed adjustment or specification variations are accomplished without loss of time or labor. Benefits of LOVEJOY finger-tip-control pulleys are reflected in an *improved* product—manufactured at a *lower* cost. Sizes from fractional to 8 hp. Ratios to 3 to 1.

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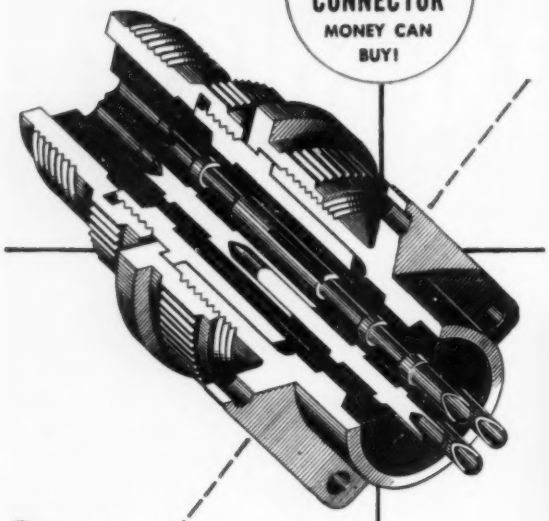

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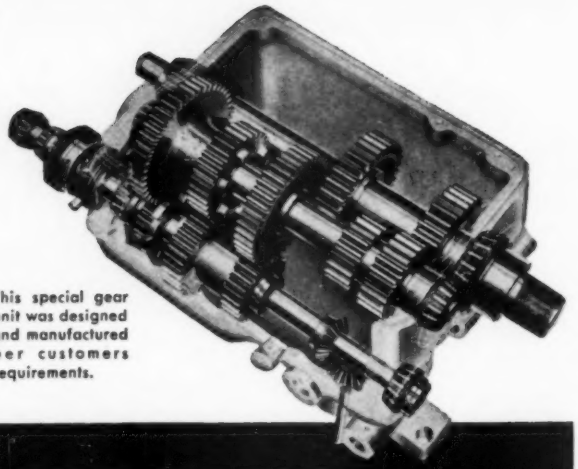

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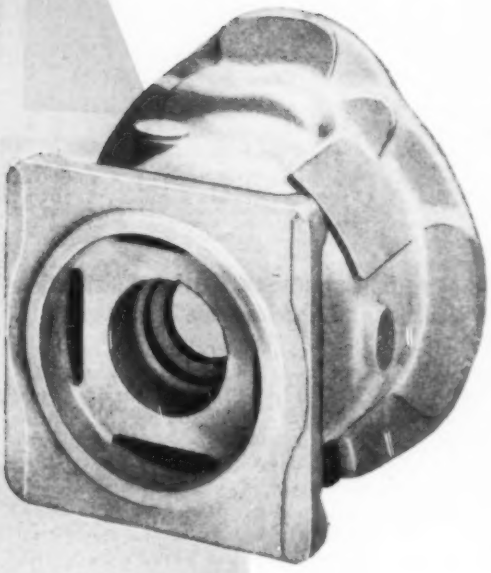

1 Check over those component parts used in your assembly process which might give you a lighter, more efficient, better looking product, or bring you savings in production if cast from light-weight aluminum.

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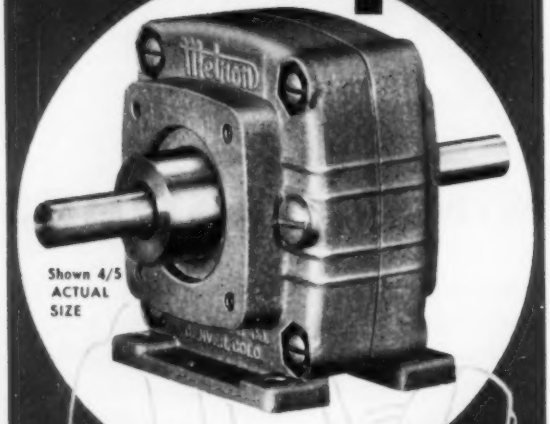

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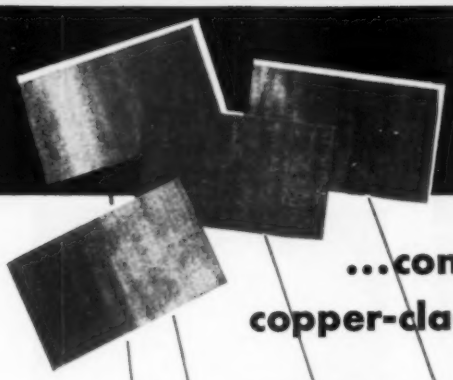

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...contributes to an improved product— copper-clad Peerless Capacitors for Bendix Radios

These copper-clad Peerless capacitors are used by the Bendix Radio Division, Bendix Aviation Corp., on the voice coil circuit and power input lead of their automobile radios. The capacitor is a combination of Peerless Insulation .004 inch thick copper-clad on both sides with .00135 inch copper foil. Punched clean, Ohmeter tests indicate no shorts between the copper foil surfaces. A minimum capacitance of 200 mmf is obtained.

This practical use of Peerless Insulation, a paper-thin grade of National Vulcanized Fibre, is typical of the countless contributions made by *the material of a million uses*—National Vulcanized Fibre—to business and industry.

National's Peerless Insulation was the *first* fish paper and has been accepted as standard ever since. It is smooth, strong and has excellent forming qualities. Write for detailed literature and engineering service information—

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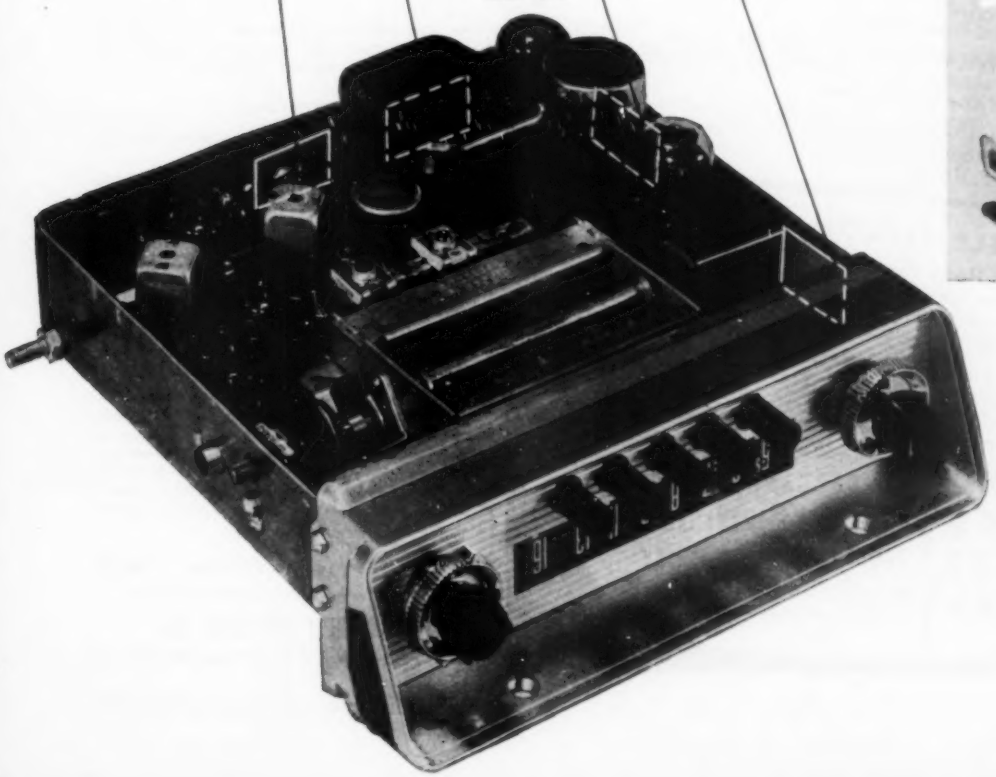

Peerless Insulation, possessing high dielectric strength plus excellent rigidity, is copper-clad on both sides to make these capacitors. The punched parts, selling for approximately 7/10 of one cent, replace commercial types of capacitors costing five or six cents.

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The bond between metal surface and the Teflon is microcrystalline in nature—an interlocking metal-permeated surface layer of the fluorocarbon.

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Chemelec Multi-Bond Cementable Teflon is a specially prepared fluorocarbon which will adhere to metal, glass, wood, fibre, asbestos, plastics, leather, ceramics, or other substances by the use of suitable commercial cement.

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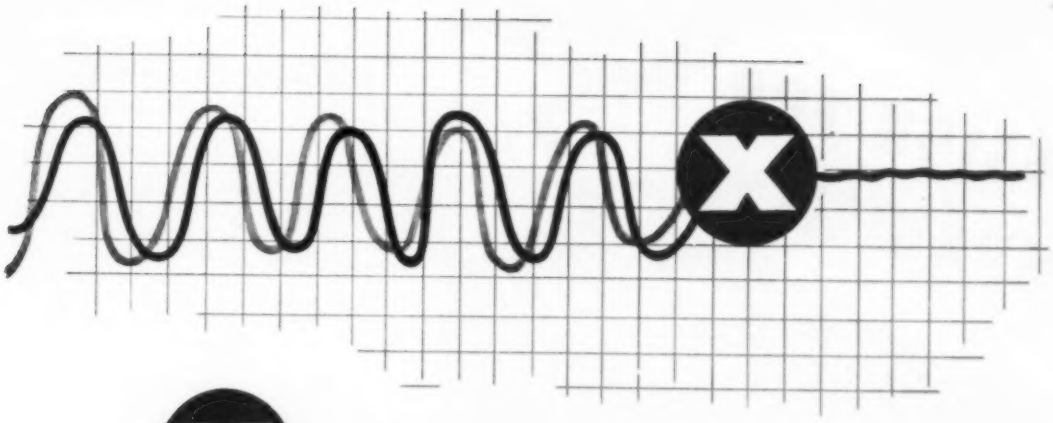

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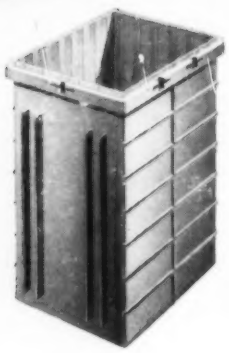

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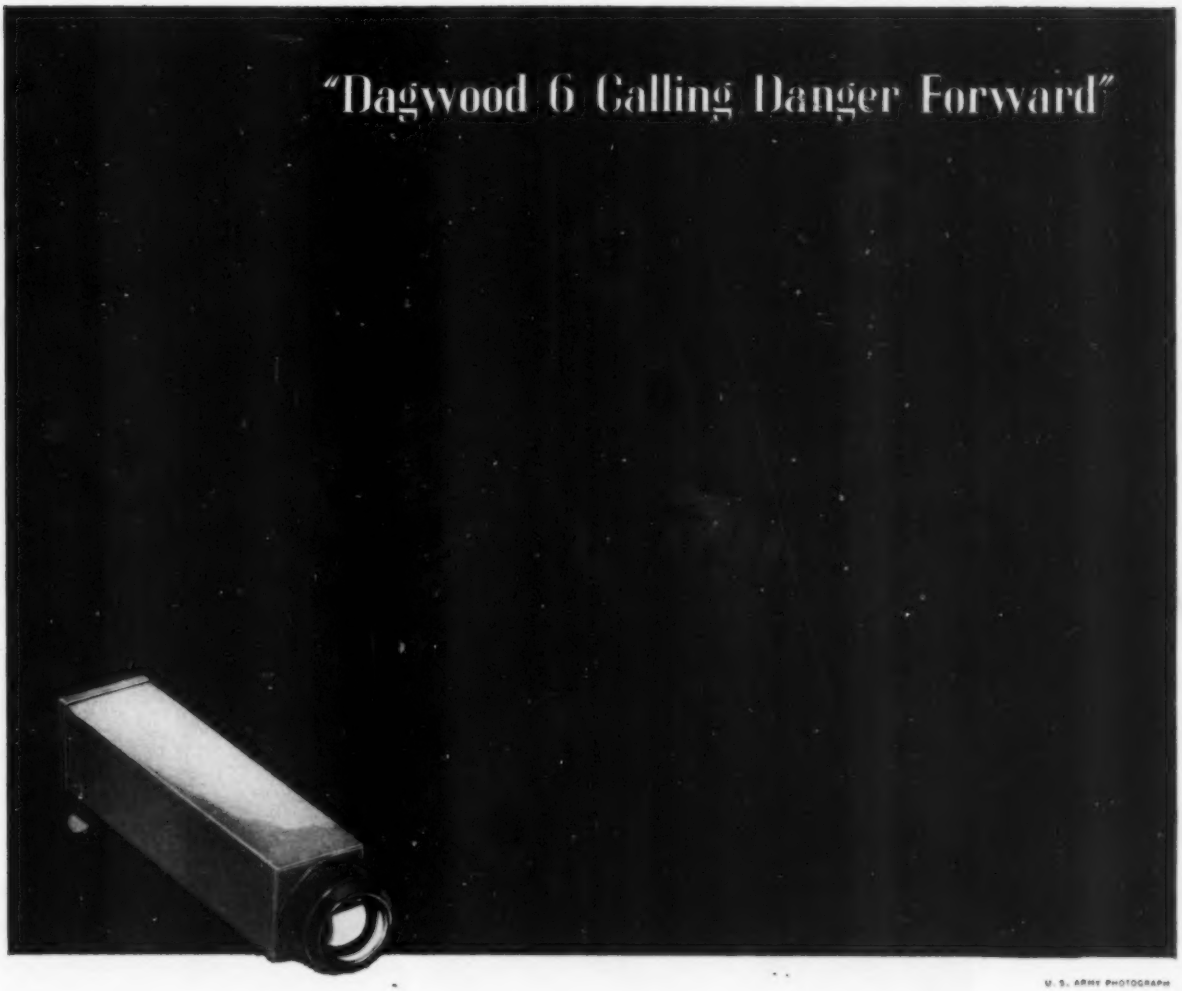

U. S. ARMY PHOTOGRAPH

G.I. Joe now puts his calls through a new field switchboard twice the capacity and one-third the size of the one toted by his World War II counterpart.

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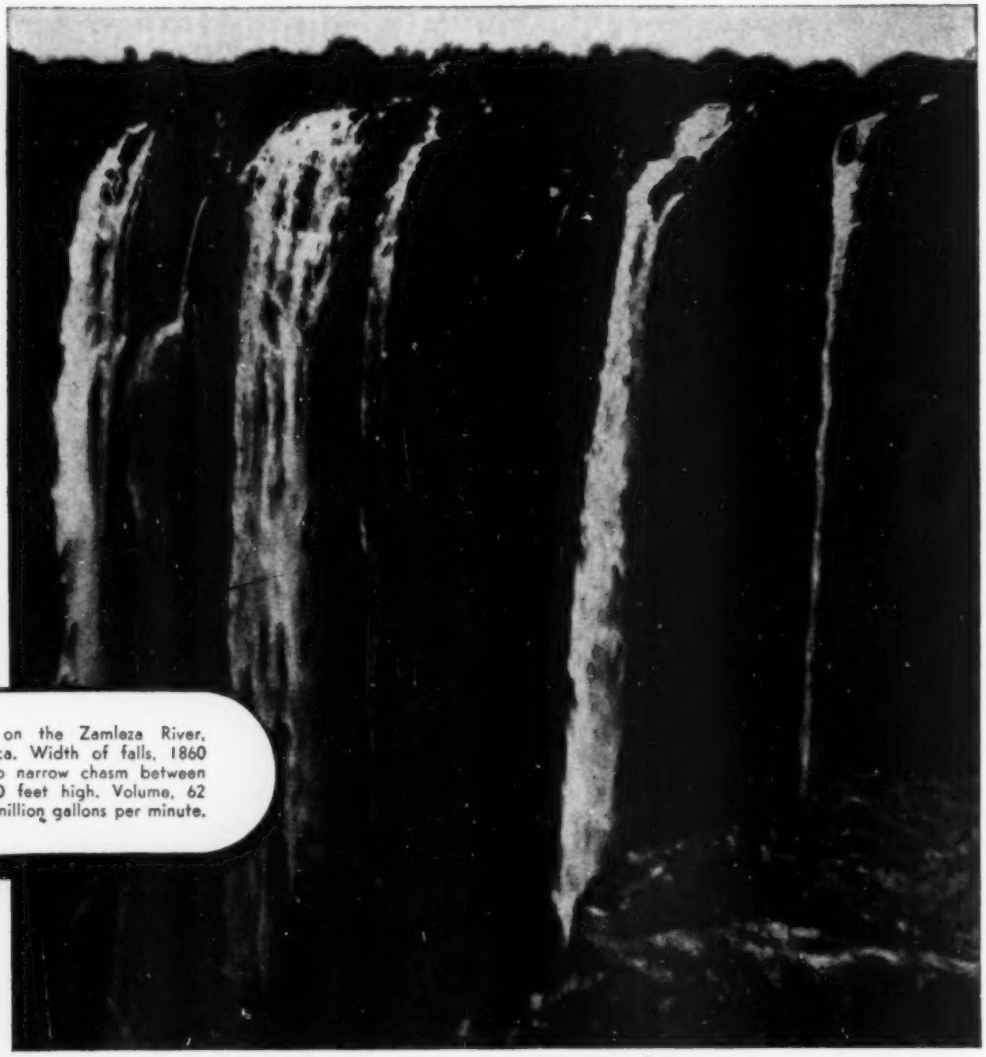

Victoria Falls on the Zamleza River, Rhodesia, Africa. Width of falls, 1860 feet. Spills into narrow chasm between sheer walls 400 feet high. Volume, 62 million to 100 million gallons per minute.

Illustrated, Model 4015—4-way, 2-position valve for directing pressure alternately to ends of double-acting hydraulic cylinder.

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A broad range of types and sizes to most effectively meet any requirement—Design Engineers, Machine Operators, Maintenance Men appreciate these Logan advantages

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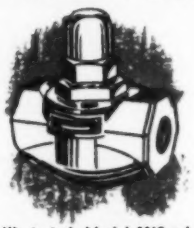

Illustrated, Model 8015 adjustable speed control valve. Install between operating valve and one end of cylinder to meter flow of oil in one direction with free flow on return.

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The Problem:

The successful operation of this coin counting machine required small pulleys, and a very long V-Belt which had to "take" a murderous back-breaking reverse bend.

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Real Solution:

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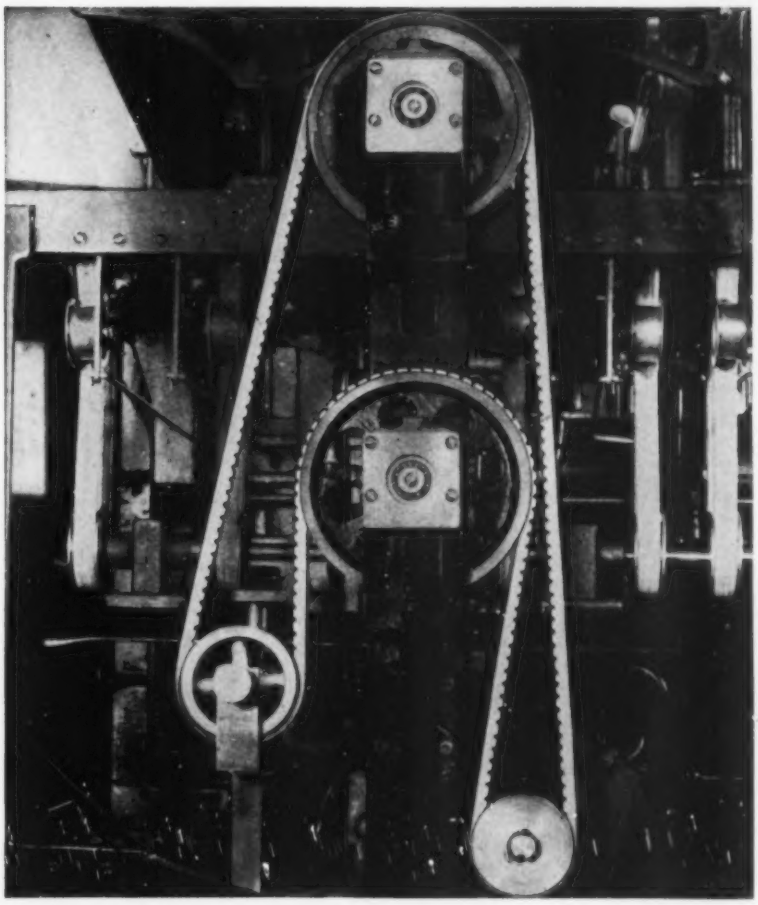
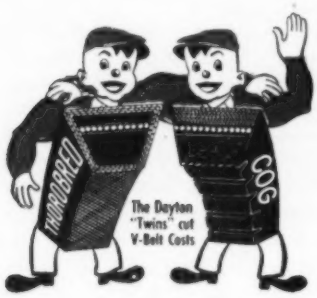
*T.M.





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Exactly how do the new synthetics compare with natural rubber?

A brief report in your *Annual HANDBOOK of Product Design for 1953* gives you the important properties of seven synthetic polymers as compared to natural rubber. In addition, the chemical and physical properties of four synthetics, along with natural rubber, are rated Poor-to-Excellent in convenient chart form.

This data, and hundreds of pages of significant design-engineering information in your *HANDBOOK for 1953*, is being utilized profitably every day by design engineers. Be sure to consult your *HANDBOOK* for help in finding the right answers to many problems facing you in your job.

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Take advantage of the wealth of permanently useful data in your *HANDBOOK*. You will receive another volume, *The Annual HANDBOOK of Product Design for 1954*, in Mid-November. It will be a worthy companion-addition to your '53 *HANDBOOK*, with an even broader and more penetrating coverage of your interests.

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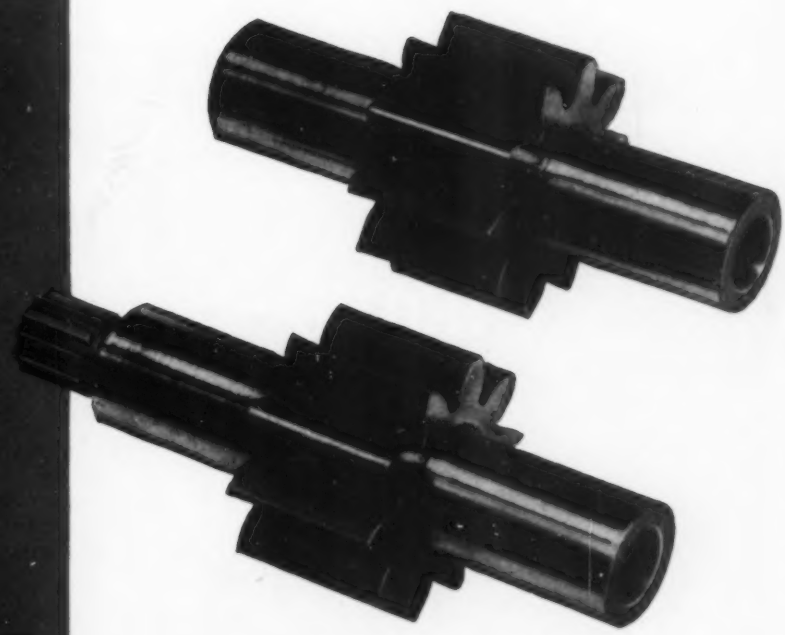

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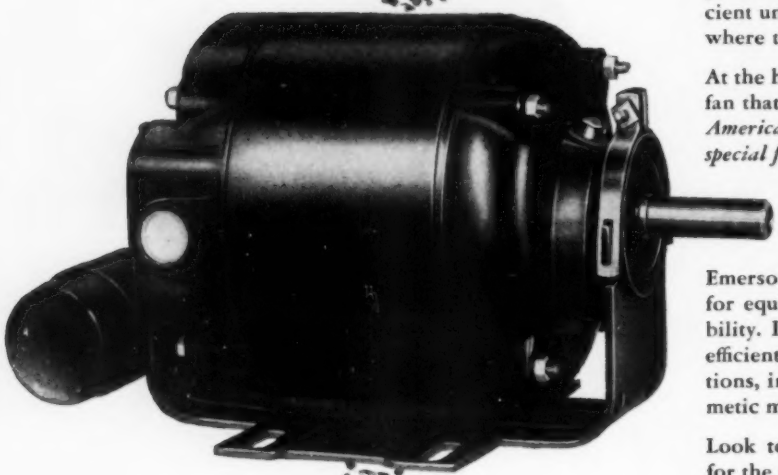


It would be a cold day in many an industrial plant without modern unit heaters. These efficient units pour out warmth and comfort right where they are needed.

At the heart of each unit is a quiet, dependable fan that sends the heat on its way. *On many of America's best known unit heaters Emerson-Electric special fan-duty motors power the fans.*

Emerson-Electric specializes in building motors for equipment with a reputation for dependability. It has done so for 63 years, and offers efficient motors for a wide variety of applications, in ratings from 1/20 to 5 h.p., and hermetic motors ⅛ to 20 h.p.

Look to Emerson-Electric if you are looking for the right motor to power your product efficiently, dependably. Your inquiry is invited.

THE EMERSON ELECTRIC MFG. CO.
St. Louis 21, Mo.

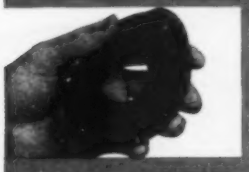
EMERSON-ELECTRIC'S unique
Twin-gineering
SERVICE
solves your power problems

Our engineers are eager to work with yours in designing and providing the correct motor for contemplated new or improved appliances or equipment. "TWIN-GINEERING" saves costly engineering "back-tracking," and may suggest short cuts and product improvement. Write today for Bulletin No. 441.

EMERSON ELECTRIC
MOTORS • FANS — APPLIANCES

NEW ADVANCED DESIGN PROMISES TIGHTEST SEAL

GET RESILIENCE NEVER BEFORE EQUALLED WITH A LEATHER PACKING!



SQUEEZE IT!

TIGHTLY CLOSED!

SPRINGS OPEN AS BEFORE!

Although Vim rubber-impregnated Packings No. 1243-3 are new in the field, they represent years of research and testing. Try them. Test them yourself. Your Houghton Man will gladly help you determine their efficiency for your particular applications. Further information can also be obtained from E. F. Houghton & Co., 303 W. Lehigh Avenue, Philadelphia 33, Pa.

HOUGHTON

rubber-impregnated

VIM LEATHER PACKING No. 1243-3

Our new advances in packing design and fabrication mean superior service in both oil and pneumatic applications.

First of all, "Vim" Packings No. 1243-3 combine the best features of both synthetic rubber and leather. You get leather's long life and strength. You benefit through rubber's non-porous, heat-resistant qualities and its resiliency.

Moreover, our special molding process produces *thorough impregnation*—a thorough bond between rubber and leather—which promises you a number of advantages no other packing offers:

1. *Less friction,* through higher resiliency and lower "drag" of leather with cylinder walls.
2. *Longer use,* due to dense structure and high tensile strength of Vim leather.
3. *Easy installation*—and a much tighter seal—because of the exceptional pliability.
4. *Greater durability,* because compound has higher resistance to oils and solvents.
5. *Wide temperature range* (—65° up to 200° F.) and wide operating pressure (0 to 15,000 psi.).

VIM LEATHER PACKING NO. 1243-3
. . . a product of

E. F. HOUGHTON & CO.
PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

Service life increased 60 times

The Zig Zag Wire Forming Machine is used to make springs for automotive seats and furniture.

This view of an automobile seat frame shows how the Zig Zag springs are used.

Zig Zag Spring Company

Los Angeles, California

Application: Slide block operating at 1000 cycles per minute and transmitting 4½ HP. A severe shock application that destroyed a roller bearing assembly after 4 days' operation and ordinary bearing bronze in less than a month.

Solution: **AMPCO METAL**

Results: Ampco Metal slide blocks have resisted wear for 5-years in round-the-clock service. Although close tolerances must be held, no adjustments due to wear have been required on Ampco Metal slide blocks during this period.

IT'S PRODUCTION-WISE TO AMPCO-IZE!

Flywheel — Centrifugally-cast.

Can forming die — Centrifugally-cast.

—with AMPCO* METAL

Sixty times longer service life and still going strong. That's the story of the slide blocks used in Zig Zag Wire Formers. And the service is tough too — involves high speeds, severe shock loads.

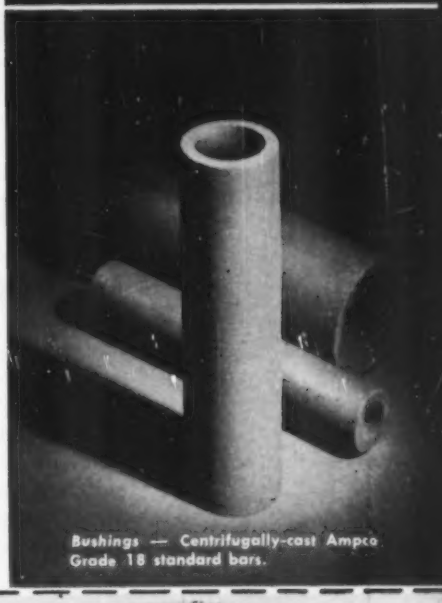
As a result, 25 Ampco Metal parts are used in the Zig Zag Wire Former. The company reports that in 5 years no Ampco Metal part has been replaced or adjusted in any machine, despite high operating speeds and tremendous shock loading.

Mr. Harry H. Norman, Chief Engineer of the Zig Zag Spring Company, says that the long-wearing properties of Ampco Metal have contributed substantially to the success of their Spring Former.

Take a look at your wear problems. Perhaps Ampco Metal is the low-cost solution. Easy to use because it is available in practically any form required—sheet, plate, sand and centrifugal castings, forgings, bars, tubes, welding wire and electrodes. Consult your nearest Ampco field engineer or write us for further information.

*Reg. U. S. Pat. Off., Ampco Metal, Inc.

Marine reversing gear component — Sand-cast.



Bushings — Centrifugally-cast Ampco Grade 18 standard bars.

Tear out this coupon and mail today!

Ampco Metal, Inc.

MILWAUKEE 46, WISCONSIN

AMPCO

West Coast Plant

BURBANK, CALIFORNIA

AMPCO METAL INC., Dept. PE-9, Milwaukee 46, Wis.

Send me your free Ampco Metal literature giving descriptions and general applications of Ampco Metal.

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Company.....

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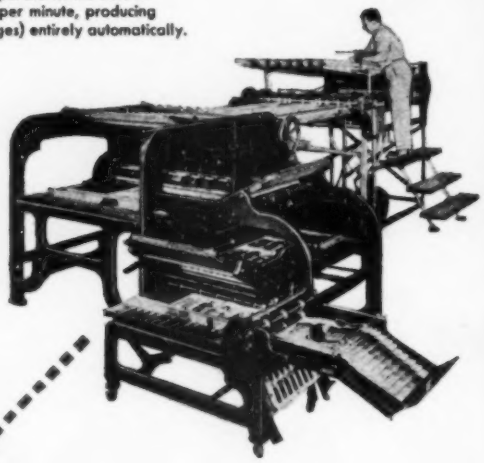
9-6

The FIRST MODEL

A MULTI-FOLDING MACHINE, built by SEMCO to operate at the rate of 450 lineal feet per minute, producing 16 folds (32 pages) entirely automatically.

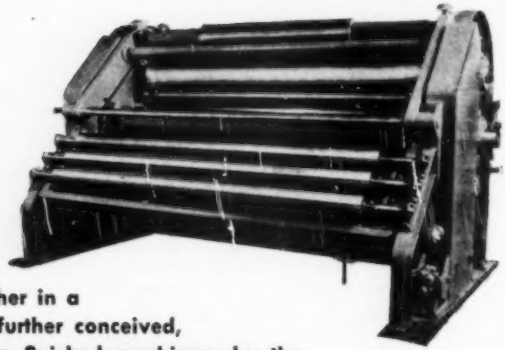


A RAMIE DECORTICATING MACHINE built by SEMCO, showing a "business end" view of the mobile unit that produces raw fibre from the fibrous RAMIE plant used for weaving into textile. Pictures of this machine in operation are considered of historical interest and are displayed in the Smithsonian Institute, Washington, D. C.

of industry's high production machinery

is often BUILT BY SEMCO

A SPECIAL PAPER COATING MACHINE built by SEMCO to a customer's specifications. Note the long rolls, ground for "kiss" contact throughout their entire length.



NEW MODELS — NEW IDEAS, whether in a visionary or concise state can be further conceived, designed, developed and built into finished machinery by the SEMCO organization. THIS IS A DIFFICULT FIELD, but the SEMCO organization has specialized in it for thirty-four years and thereby has become most proficient.

Write today for the SEMCO brochure "Ready to serve you".

SEMCO

SERVICE MACHINE CO. INC.

152 Miller Street • Elizabeth 4, New Jersey

G.P.&F. Produces 1,000,000th Ammunition Box

The Sheboygan, Wis., plant of Geuder, Paeschke & Frey Co., recently celebrated the completion of the one-millionth .30-cal. ammunition box it is now producing for the government. Shown in the photo above are, left to right: William Livingston, Assistant Chief of Purchasing, Chicago Ordnance District; Frank T. Frey, G. P. & F Executive Vice-President; Major E. A. Smith, personal representative of Colonel Haskell, Commanding Officer, Chicago Ordnance District; August K. Paeschke, G. P. & F. President; Major R. E. Ryan, Commanding Officer Milwaukee Regional Office, Chicago Ordnance District. G. P. & F.'s Sheboygan branch plant is devoted entirely to military production.

• Whether your requirements are for military use or civilian use—whether you need an ammunition box or a washing machine tub—if it's stamped or drawn, chances are that G. P. & F. can do it for you. When you think of G. P. & F., think of over 1000 skilled people . . . 15 acres of production facilities . . . 293 deep draw and stamping presses . . . 97 welding machines . . . a complete tool and die department.

METAL STAMPINGS FOR EVERY TYPE OF CIVILIAN AND MILITARY USE

Automobile Oil Pan
Hot Dip Lead Coated

Washing Machine Tub
Seamless Drawn—
Vitreous Enameled

Radio Case
U. S. Signal Corps

Base for Power Lawn Mower
Seamless Drawn Steel

Aerial Delivery Container
U. S. Air Force

Deep Fat Fryer Pot
Stainless and Carbon Steel

Scale Platter
Vitreous Enameled

Commercial Fruit Juicer
Stainless Steel

Tub and Cover for Portable Dishwasher
Seamless Drawn Aluminum—
Baked Enamel Finish

G.P.&F.

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WELDING • SPRAY FINISHING
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GEUDER, PAESCHKE & FREY CO., 1505 W. St. Paul Ave., Milwaukee 1, Wis.

This book tells why Forgings are used for the toughest work loads

Engineering, production and economic advantages obtainable with closed die forgings are presented in this Reference Book on Forgings. Write for a copy.

There is no substitute for the strength and toughness inherent in closed die forgings. A product fortified with the metal quality found in forgings outperforms other products. Check all the aspects of a problem part with the unrivaled economic and mechanical advantages of closed die forgings and the closed die forging process for producing parts. Double-check all parts, particularly those which are subjected to great stress and strain. Then consult a Forging Engineer about the correct combination of mechanical properties which closed die forgings can provide for your product.

DROP FORGING ASSOCIATION
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Please send 64-page booklet entitled "Metal Quality—How Hot Working Improves Properties of Metal", 1953 Edition.

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High Speed

PHOTOGRAPHY IN DESIGN

High-speed photography not only offers the designer all of the advantages generally associated with ordinary stills and moving pictures, but also puts at his disposal a means for actually studying motions and events that until recently have never been "stopped" or slowed down to perceptible speeds.

Product Engineering's Special Editorial report on this subject gives designers a thorough study of basic considerations in the field of high-speed photography, operation and characteristics of major types of high-speed cameras, and some typical fields of application.

Included with this report is a fully illustrated Chart of High-Speed Camera Systems, headed by a master diagram that shows the essential elements of high-speed camera optical systems.

Reprints (including chart) available at 35¢ per copy

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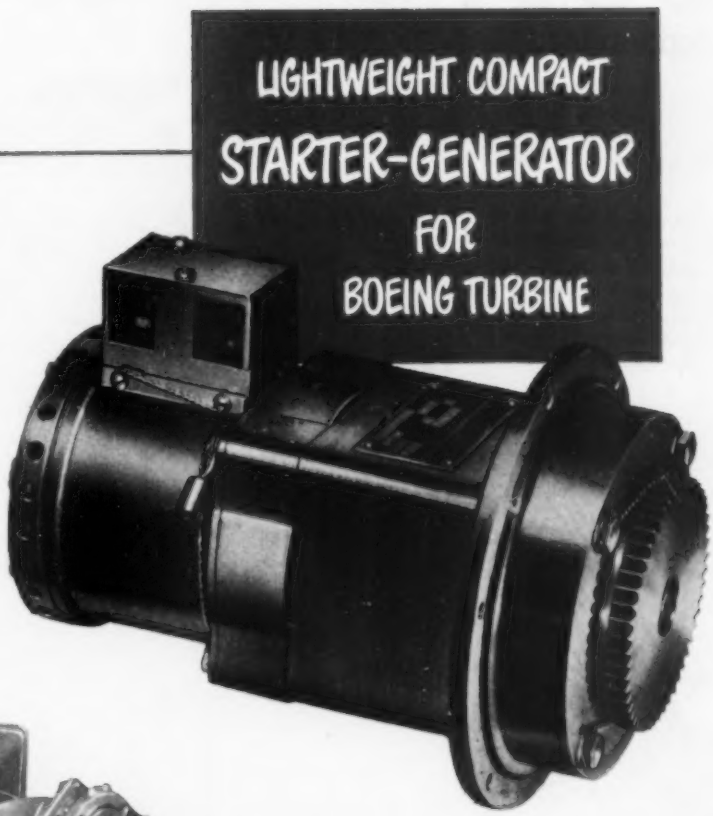
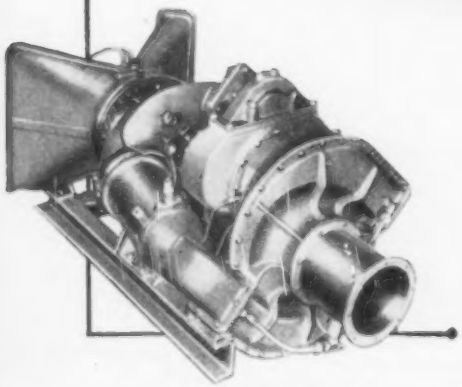
New York 36, N. Y.

EEMCo technical bulletin

LIGHTWEIGHT COMPACT STARTER-GENERATOR FOR BOEING TURBINE





The starter-generator used on the Boeing 502 Turbine is another example of EEMCO ability to design and produce motors to solve special problems.

This 15¾ pound unit brings the turbine up to 6000 RPM for firing and is able to support the starting effort after firing, up to 10,000 turbine RPM. When the turbine is operating, it acts as a generator without mechanical change-over or gear box and is capable of delivering 30 amps continuously.

Compactness and light weight result from the direct mating of the starter-generator with engine gear train, making it an integral part of the turbine.

High temperatures are involved since the installation is in close proximity with the combustion chamber.

This EEMCO starter-generator is ideal for use on all types of small turbines wherever a combination of starting and generating is required.

ELECTRICAL ENGINEERING AND MANUFACTURING CORP.
4612 WEST JEFFERSON BOULEVARD
LOS ANGELES 16, CALIFORNIA

3-515

BACK IN THE 1880's

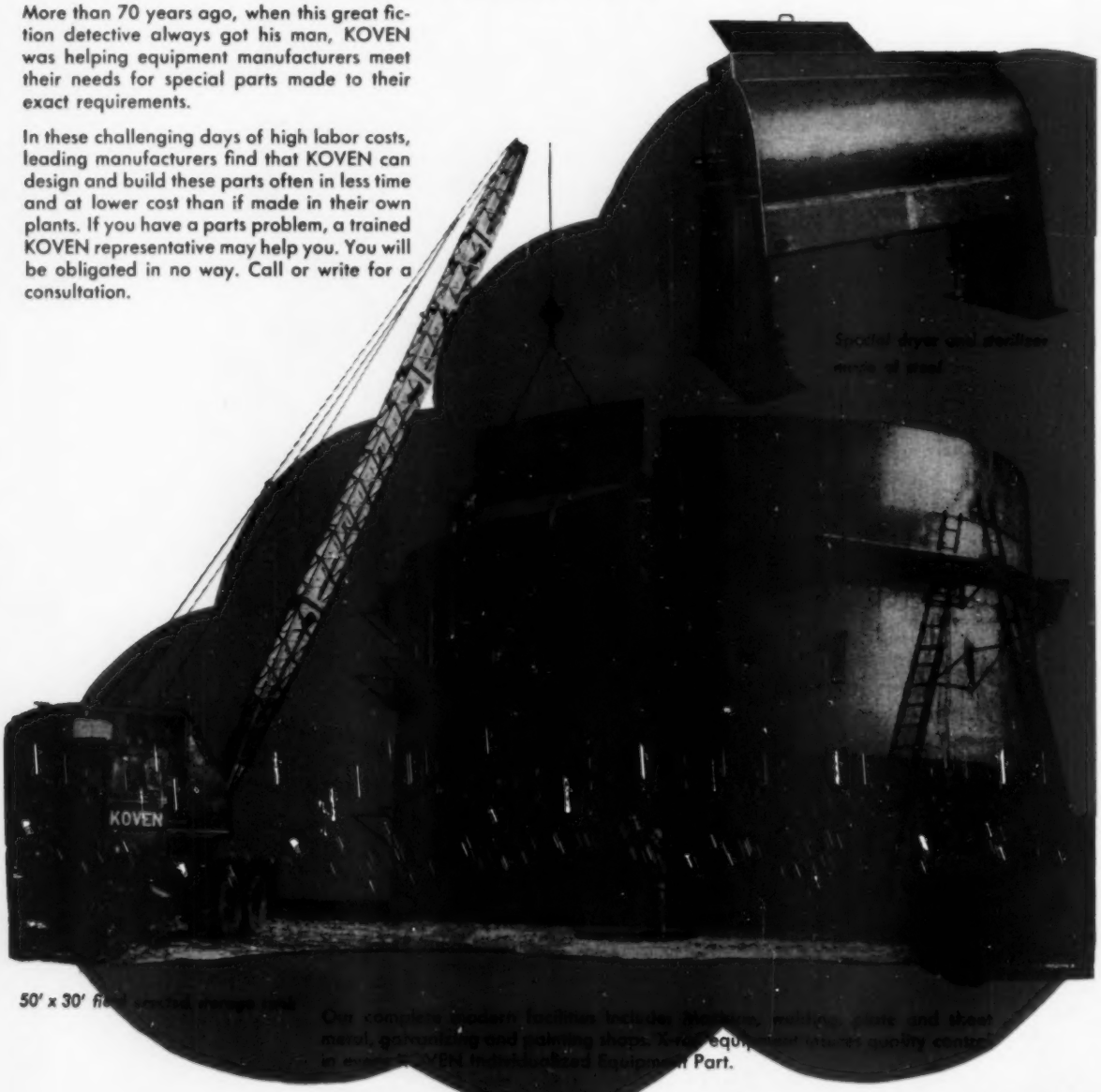
WHEN THE FAMOUS CHARACTER SHERLOCK HOLMES WAS CREATED

Koven

WAS MAKING INDIVIDUALIZED EQUIPMENT PARTS

More than 70 years ago, when this great fiction detective always got his man, KOVEN was helping equipment manufacturers meet their needs for special parts made to their exact requirements.

In these challenging days of high labor costs, leading manufacturers find that KOVEN can design and build these parts often in less time and at lower cost than if made in their own plants. If you have a parts problem, a trained KOVEN representative may help you. You will be obligated in no way. Call or write for a consultation.



50' x 30' fi

Part.

PLANTS: Jersey City

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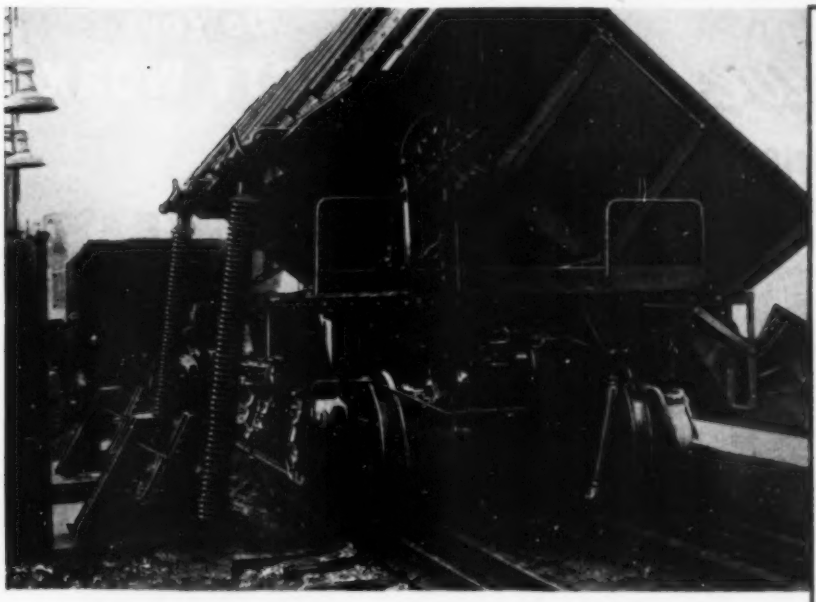
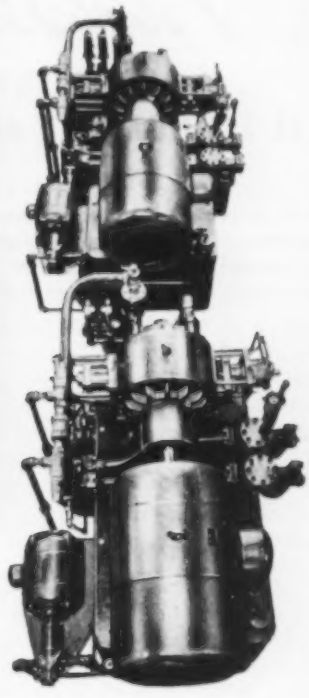
L. O. KOVEN & BRO., INC.
145-C Ogden Ave.
Jersey City 7, N. J.

KOVEN FOR INDIVIDUALIZED EQUIPMENT SINCE 1881

HOW TO DUMP A SLAG CAR in 2 minutes





with HELE-SHAW

DUMPING A SLAG CAR at Jones & Laughlin's in Pittsburgh is "easy as rolling off a log." A new electro-hydraulic system... two hydraulic jack cylinders, each served by an American Engineering Hele-Shaw Pump... enables one operator at the push button controls to dump a car within two minutes. Synchronized pump action insures simultaneous functioning of the jacks, and identical speeds.

The Hele-Shaw is a radial-piston, variable displacement fluid power generator for oil pressures up to 3000 p.s.i. It is superlatively rugged... engineered and built for longest service life and maximum dependability. It is easily applied to the machine it serves... installed on the machine or remote from it. Discharge is infinitely variable from zero to maximum. Capacities range from 0.5 to 110 g.p.m.

Your American Engineering representative is qualified to analyze your hydraulic requirements, to design, to engineer and to furnish the necessary power units, and assume *local* responsibility for continuous, efficient service. He can also make unusually good delivery under present conditions.

Mail the coupon and we will send you full information about the Hele-Shaw . . . or the AE Hydramite for pressure to 5000 p.s.i.

At top: Dumping a car at the J&L slag disposal dock. Above: The two Hele-Shaw pumps which control the hydraulic jacks... The new facilities were devised by J&L engineers and the complete electro-hydraulic system was designed and built by Benjamin Lassman & Son, Glenshaw, Pa., AE representative serving western Pennsylvania and West Virginia.

WHEN IT'S HIGH PRESSURE IT'S AMERICAN!

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AE Products are: Taylor and Perfect Spread Stokers, Marine Deck Auxiliaries, Hele-Shaw and Hydramite Fluid Power, Lo-Hed Hoists, Lo-Hed Car Pullers.

American Engineering Company
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Gentlemen: Kindly send me complete information about the ☐ Hele-Shaw Pump. ☐ Hydramite.

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IF YOU'RE BENT ON CUTTING COST CORNERS . . .

Fusionweld

STEEL TUBING IS ECONOMICAL *and* QUALIFIED

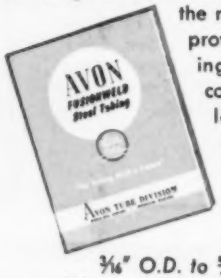
HERE'S WHY! Avon thin wall steel tubing—"as welded," hard drawn, or soft annealed—cures plenty of cost and production headaches . . . has successfully supplanted other types of tubing—copper, aluminum, brass and steel,—where reliability, performance and price *all* meet at the cross roads.

Hundreds of diversified manufacturers specify Avon Fusionweld Steel Tubing for its clean, smooth O. D. . . . for its tensile strength, greater resistance to vibration and fatigue . . . extreme ductility and adaptability to the toughest tube forming operations . . . and for its hi-pressure tested advantages in hydraulic and pneumatic applications.

Avon engineers can assist you in cutting cost angles—whether its in tubing by the coil, or by the car load.

HERE'S HOW! Avon Fusionweld is produced by our own exclusive, hi-cycle, resistance welding methods to provide tubing of superior quality to serve the most critical needs for bending, beading, flaring, coiling, slotting, threading, knurling, perforating and swaging. That spells lower cost forming. Fusionweld tubing is held to closer tolerances on wall thickness—that guarantees uniform strength, less scrap loss!

The consistent tubular strength achieved by Fusionweld is due to its unique single wall construction . . . more uniform grain structure in both wall and welded areas. That insures maximum resistance to tearing, cracking or checking at the weld or wall. Its smooth O. D. achieved by the new Fusionweld process likewise provides an ideal surface for plating operations. These features, coupled with approval by the leading testing laboratories, plus a constantly expanding list of prominent tube users is your positive safeguard when specifying Fusionweld—*"The Tubing With a Future."*



3/16" O.D. to 3/8" O.D. Plain or Terne Coated
We can fabricate tubing forms to your specifications.

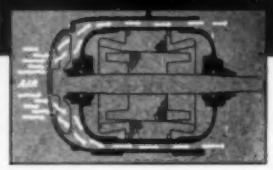
AVON TUBE DIVISION

HIGBIE MANUFACTURING CO.

ROCHESTER MICHIGAN

Let These MOTORS Do Your DIRTY WORK

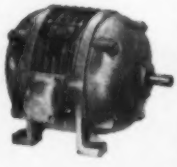
They're built to ignore dirt, dust and corrosive vapors



SMITHway totally enclosed fan-cooled motor—a frame within a frame and both are cast iron. Efficient, high-capacity, double-locked fan forces air through self-cleaning ducts. Heat is dissipated—dirt, dust and corrosive vapors can't get into the sealed motor.

CAST IRON construction is one of the many outstanding features which makes these motors superior under service conditions involving dirt, dust and corrosion. Cast iron frame, cast iron end bells—the complete enclosure is cast iron—all exposed parts are cast iron. Ideal for petroleum, chemical and other rugged industrial applications.

SMITHway totally enclosed fan-cooled motors are built to standard NEMA frames to meet the highest standards of electrical performance. TEFC motors are built in sizes from 5 to 125 HP. Parts and service available throughout U.S.A. Get complete information from nearest office or write today.



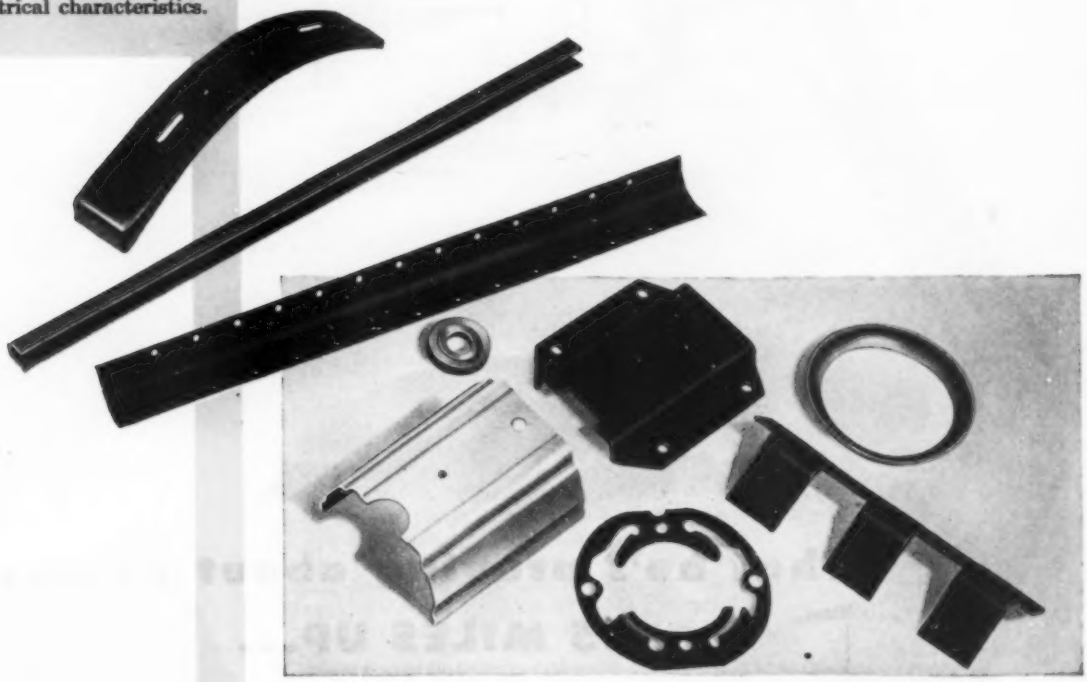
SMITHway totally enclosed non-ventilated motor. Standard NEMA frames. Cast iron construction of all exposed parts keeps these motors, by the thousands, on the job regardless of dust, dirt and corrosive conditions. Available in ratings from 1 to 5 HP.

A.O.Smith

ELECTRIC MOTORS

TAYLOR Forming Materials are specially made for use in intricate shapes, compound curves and relatively deep draws. They are available with a wide variety of physical, mechanical and electrical characteristics.

Want to make something of them?



Make them into all kinds of panels, guards, barriers, ribs, masks, covers, ducts, containers, shields, shims or any other complicated formed part your product may require. While many grades of Taylor Vulcanized Fibre and Laminated Plastic can be formed to some degree, these four grades are ideally suited for most forming operations.

LAMINATED PLASTICS:

Grade C-7—for applications requiring toughness, resilience, mechanical strength and abrasion resistance.

Grade XX-7—for applications where mechanical strength is secondary to good electrical properties and low cost.

VULCANIZED FIBRE:

Trunk Fibre—for applications requiring good mechanical strength, toughness, abrasion resistance, surface finish and resistance to organic solvents.

Taylor Insulation—for applications requiring superior dielectric strength, toughness and abrasion resistance as well as good mechanical strength.

Make your products better and easier to assemble. Call your Taylor Engineer, he will be glad to work with you on your design problems and recommend the Taylor material that can be best formed to meet your particular requirements. Other grades of Taylor Vulcanized Fibre . . . as well as Phenol, Melamine and Silicone Laminated Plastics . . . may also fit into your design plans. Your Taylor Engineer will be glad to show you samples and discuss specifications.

Taylor Fibre Co., Norristown, Pennsylvania—La Verne, California

TAYLOR
Laminated Plastics
Vulcanized Fibre

What he's proving about pumps 15 MILES UP...

may hold an idea YOU can use

A shaft seal, for example, that stays vapor-tight even at —70°F. And at an atmospheric pressure only 1/30 that at sea-level.

Or pumps to handle low-boiling-point liquids, (like aviation gasoline), without troublesome vapor-lock or cavitation.

Or pumps to work at 1,000-pound pressure dependably in desert heat *and* Arctic cold.

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These, and many other pumping problems have been solved by the Accessories Division . . . then *proved* in our High-altitude Lab. where engineers can "fly" a pump to 75,000 feet without ever leaving the ground

Your pump requirements, present or future, can find a prompt solution from the broad experience the Accessories Division has had in aircraft fuel pump development. After all, Thompson Products is the leader in manufacturing pumps for aircraft and commercial production. Write us, describing your application.

ACCESSORIES DIVISION

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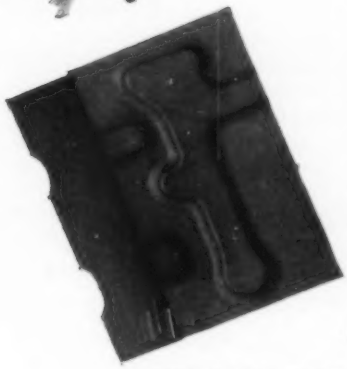
EASY . . . INEXPENSIVE TO POST-FORM THESE PARTS WITH

New DILECTO CF-1



- ***Non-After-Glow characteristic***
- ***A canvas-based laminate***
- ***Post-Forms to shapes in inexpensive cold molds***
- ***Excellent mechanical strength***
- ***Resists abrasion, has long life***
- ***Easily machined and punched***

Where can you use this new canvas-based C-D-F "Post-Forming" Dilecto grade CF-1? Presently it's used for a multitude of aircraft and semi-structural parts . . . as ribbed panels, fan blades and ammunition bay liners, guards and cover frames . . . as ventilating ducts, battery box containers . . . switch covers, thermostat mounting plates, etc. CF-1 has a tremendous potential in electrical as well as other industries because of its strength and light weight.

"Post-Forming" Dilecto CF-1 is easy to work with. Heated until pliable with infra-red, electric ovens, strip heaters or hot plates, or immersed in molten alloys or hot oil, it is then quickly placed in a cold mold and pressed or formed until cold enough to retain the desired shape. Inexpensive molds can be made from hard wood, cast or laminated plastics, steel and metal alloys. Normally C-D-F supplies Dilecto CF-1 in sheets from 1/32" to 1/4" thicknesses.

C-D-F's sales engineers (offices in principal cities) will cooperate with your designers and production experts. C-D-F also forms and fabricates Dilecto to your specifications. Write for technical bulletins describing Dilecto CF-1 as well as other grades of Post-Forming Dilecto.

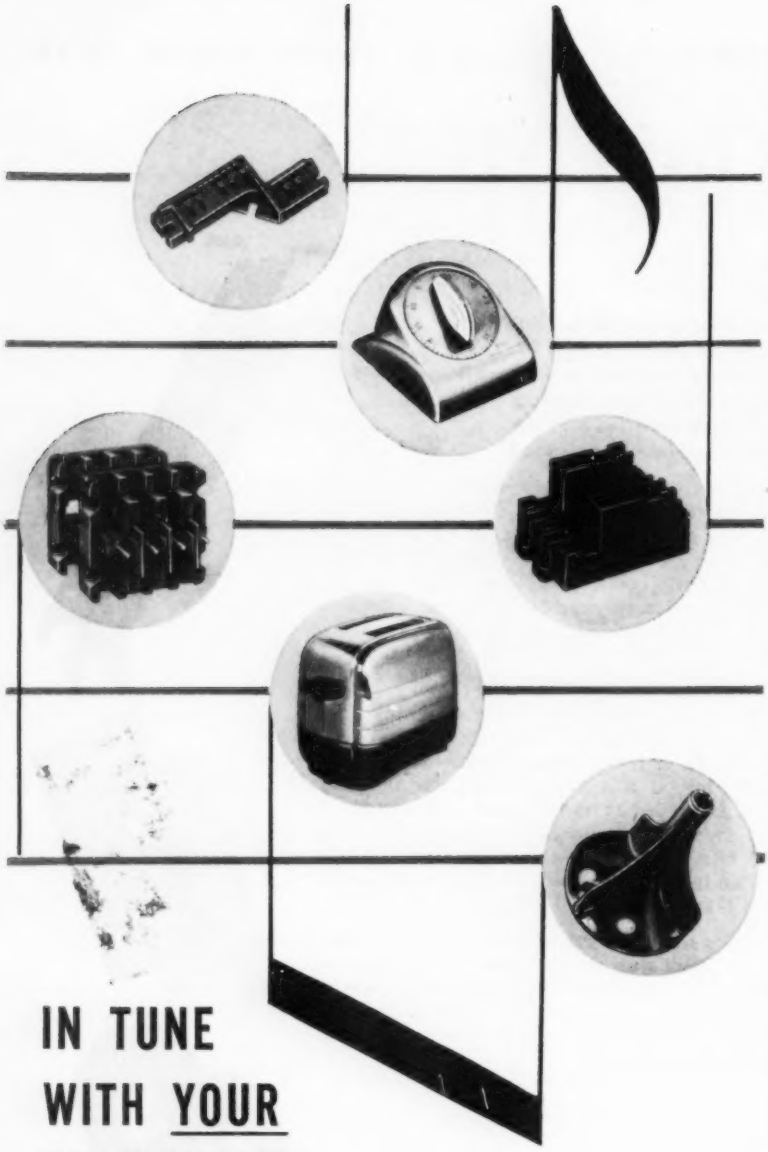
NON-AFTER-GLOW — Post-Forming Dilecto CF-1 incorporates special chemicals in the varnish that produce no apparent after-glow once an ignited specimen has been extinguished. This product complies with the SAE-Aeronautical Material Specification AMS-3605, latest revision.

SILICONES, TOO — C-D-F offers other post-forming grades of laminated Dilecto: Grade GB-SF is a glass-base Silicone laminate furnished in a semi-cured state for forming pieces where high heat resistance and low dielectric losses are required. Can be formed into armature slot insulators, rectangular coil forms, primary-secondary cylindrical or rectangular insulators for dry type transfomers, etc. Grade XF Dilecto is a paper-base grade for mechanical applications where electrical properties are secondary.

THE NAME TO REMEMBER CDF **FOR POST-FORMING DILECTO LAMINATED PLASTICS**

Continental-Diamond Fibre Company

NEWARK 40, DELAWARE



IN TUNE WITH YOUR PRODUCTION

Watertown Plastic Parts are Designed To Help You Turn Out Better Goods... Faster

Here at Watertown our aim is to provide you with plastic parts that do more than add utility and beauty to your product. Our complete engineering, laboratory and design facilities go to work for you to produce custom molded parts that will fit into your production scheme. We are prepared to handle any custom molding job — regardless of size or shape — in practically any plastics material — by compression, injection, or transfer — from idea to delivery. Why not let our engineers wrestle with your problem? Write today to . . .

WATERTOWN MFG. CO.

500 ECHO LAKE ROAD, WATERTOWN, CONNECTICUT

Is there any data available on elastic elongation of chains?

Actually, until very recently there has been little or no data available to designers regarding elastic elongation of various types of chains. A report in your *Annual HANDBOOK of Product Design for 1953*, however, for the first time outlines and shows in table and graph form the results of extensive tests to determine accurately the average elastic elongation of single strand ASA roller chain, double pitch conveyor chain, and cable chain.

The *HANDBOOK*, published for the first time last November, has earned the acclaim of design engineers everywhere for its abundance of up-to-the-minute and lastingly useful product engineering data. All the vital information in the *HANDBOOK* is separated into ten major classifications and fully indexed so that you can easily find exactly the data you particularly want. For example, the report mentioned above, titled "Elastic Elongation of Chains," is found in the section on *Power Transmission*.

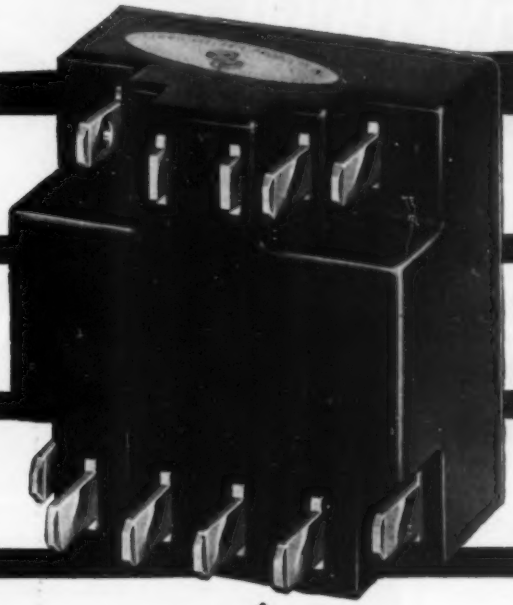
Another edition will be along to join your '53 *HANDBOOK* in November. *The Annual HANDBOOK of Product Design for 1954* will present an even broader, more informative selection of data important to you in your work. Again, you'll receive the *HANDBOOK* with your regular subscription to *Product Engineering*, at no extra cost.

Product Engineering

330 West 42nd Street
New York 36, N. Y.

LOOKING FOR Something New IN SWITCHES?

(This one helps SELL room air conditioners)



POSITION I
"VENTILATE"
(Evaporator, on full)

POSITION II
"EXHAUST"
(Condenser, on full)

POSITION III
"COOL and EXHAUST"
(Evaporator, on low; Condenser, on full; Compressor, on)

POSITION IV
"DEHUMIDIFY"
(Same as position III)

POSITION V
"SUMMER COOLING"
(Evaporator and Condenser, on full; Compressor, on)

POSITION VI
"SLUMBER COOLING"
(Evaporator and Condenser, on low; Compressor, on)

POSITION VII
"HEATING"
(Evaporator, on full; 1250-watt heater, on)

POSITION VIII
"OFF"

Special 8-POSITION switch
MODEL 190

The designing and building of *circuit selector switches* is an important part of Ferro's business. And we're not too big to fuss with *your* special requirements, provided the potential production volume justifies the effort—*both* for you and for us.

Whether your problem is one of space and compactness or the best handling of an intricate wiring pattern, you'll find interested, competent "first aid" here at Ferro. You'll find also that the finished product is *right* due to our small labor turnover and rigid testing and inspection system.

Illustrated above is one of our more elaborate switches. Shown at the right is a simple, 3-position model. Somewhere between the two may be the special switch you are looking for. *Why not write* and tell us your requirements?

FERRO ELECTRIC PRODUCTS, INC.
A Subsidiary of Ferro Corporation
KIRKLAND, ILLINOIS

FOR EXTRA HEAVY DUTY Service

SPECIFY VELVETOUCH

ALL-METAL CLUTCH PLATES FACINGS AND BRAKE LININGS

Whether you're designing the clutch for a twenty ton prime mover or the brake for a fractional horsepower motor, it will pay you to specify Velvetouch. Because Velvetouch is built for extra heavy duty service!

Unlike ordinary friction material, Velvetouch is made from powdered metals, compressed and fused to a strong steel backing plate. As a result, it runs cooler, lasts longer . . . can't deteriorate or burn like asbestos. And by changing the metal mixture, the friction characteristics of Velvetouch can be altered to meet specific clutch and brake requirements.

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* PORTLAND—636 N. W. 18th Ave., Portland 9, Oregon

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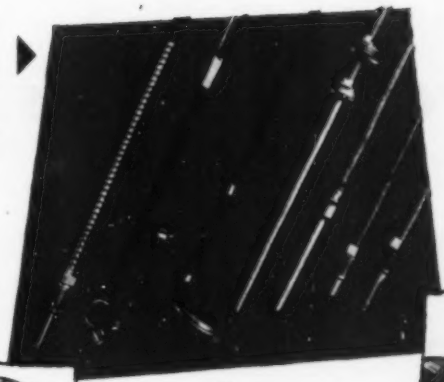
Flexible, semi-rigid, and rigid harnesses are custom-made by Revere for virtually all aircraft engines and test stand operations and for many industrial uses. Submit your special harness application today.



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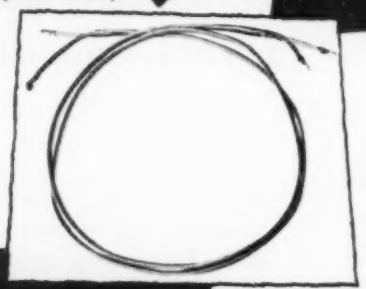
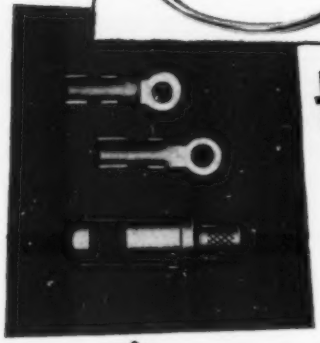
Stranding, wrapping, twisting and asbestos serving equipment enables Revere to produce thermocouple wire with cotton, glass, stainless steel, tinned copper and silver plated copper in accordance with AN and MIL Specifications.





for more accurate temperature readings contact Revere ...your dependable source of supply

CONNECTORS

Thermocouple Adapters, Terminals, Fire Wall Connectors and Resistors are manufactured in accordance with AN-3540-2 and AN-3541-1 specifications. All are ruggedly constructed to guarantee long life under hard usage.

SEND FOR FREE BULLETINS!

EXTRUDED PLASTIC WIRE

A new high temperature thermoplastic insulation extruded over wires of all types, developed for use in hermetically sealed equipment or hot wiring jobs. Available in 14 colors.

Accuracy—dependability—long life are three necessary attributes of temperature measurement equipment. On all 3 counts Revere products have established unsurpassed performance records. Recognition of their quality by the government and industry has made Revere one of the foremost producers of thermocouples, thermocouple wire, harnesses, plastic-insulated wire, and accessories!

Revere's modern plant is capably staffed and equipped to offer complete and efficient service to all your temperature measurement requirements. Many standard stock items are available for immediate shipment. Special orders can be handled without delay. For more detailed information write to Revere Corporation of America, Field Engineering, Dept. 1, North Colony Road, Wallingford 2, Connecticut.

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WALLINGFORD 2, CONNECTICUT, U.S.A.

precision instruments for aircraft and industry

If you use relays—Clare's New Plant is

CLARE RELAYS are now built in the most modern plant ever specifically designed for relay manufacture

Light eight times better than average for industrial plants —75 foot candles of shadow-proof light at bench level.

All air electrostatically washed —avoids danger of contamination in such operations as contact welding.

100% inspection of all Clare relays with most modern test equipment. Light on this test set gives 125 foot candles.

• Building of precision relays requires more than technical skill. It requires an atmosphere of utmost freedom from dirt. Air temperature and humidity must be closely controlled. Assembly of small parts must be done under powerful, yet shadow-free light.

All these important features and many more are provided in the new Clare relay plant. Never before have so many manufacturing advantages been provided in one plant—for one purpose—to give you relays of unequalled quality.

Quality and long-life dependability of Clare relays have made them first choice of designers as components for critical equipment. Wherever failure cannot be tolerated, when only the best is good enough, Clare relays are indicated.

Two important factors contribute to this Clare superiority. Production of relays has always been the exclusive business of

***FIRST* IN THE INDUSTRIAL FIELD**

BIG NEWS!

C. P. Clare & Co. This is a young-minded progressive organization, ever alert to discover and test new and better materials and manufacturing methods.

The new plant is the product of years of research and experiment. It is the natural development of Clare's unwillingness to offer their customers anything less than the most perfect relays that can be built.

• • •

If yours is a product whose long life, reliable performance and freedom from maintenance depend on the use of relays—it will pay you to know ALL about Clare relays. A sales representative, fully experienced in every type of relay problem, is located near you. Consult him, or write C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials, Ltd., Toronto 13. Cable Address: CLARELAY.

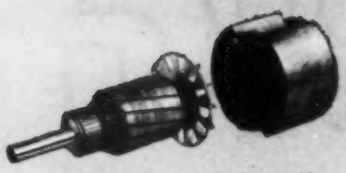
CLARE RELAYS

Automatic control of air temperature and humidity increases accuracy of assembly and adjustment of delicate parts.

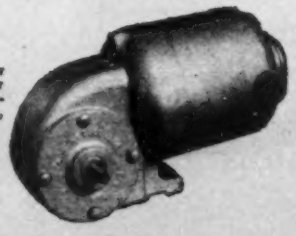
Multiple test circuits of variable voltages on bench channels facilitate adjusting of relays to customers' specifications.

Diminutive parts of high frequency impulse relay require laboratory-clean assembly conditions.

An Idea to Reduce Costs... Improve Product Operation



Universal motor parts for portable electric tools, garage equipment and other industrial devices.

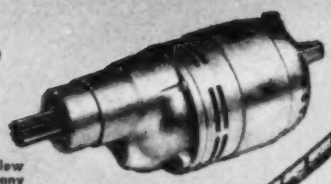


Ruggedly designed motor with triple thread worm gear reduction for vending machines, advertising displays, and similar applications.

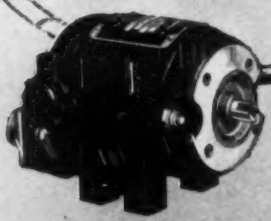
Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Rugged construction is a major factor in the reliability of this motor widely used in the field of mechanized equipment.



Geared motor head with low output shaft speed for many slow speed heavy-duty drives.



Compactly designed motor developed for metering pump and special instrument service.

Every Lamb Electric Motor is specially designed for the product or device it is to drive. This means that both mechanical and electrical characteristics are engineered for the exact requirements of the particular application.

Special engineering in Lamb Electric Motors often results in savings in space, weight and cost factor and assures optimum product operation. These are some of the reasons why more and more of America's finest products are being powered with Lamb Electric Motors.

The Lamb Electric Company • Kent, Ohio

In Canada: Lamb Electric–Division of Sangamo Company Ltd.–Leaside, Ontario

THEY'RE POWERING AMERICA'S *Finest* PRODUCTS

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Precision Dyna-seal plays vital role in leak-proof operation of this Hydraulic Relief Valve

Dyna-seal®

Synthetic rubber sealing member bonded to steel ring for sealing circular flat surfaces — no grooves necessary!

Rivett Lathe & Grinder, Inc., uses a *Precision Dyna-seal* in order to simplify the construction of this Balanced Piston Hydraulic Relief Valve. Simple to install and maintain, the valve must give long, leak-free service. The *Precision Dyna-seal* plays a vital part in the valve's efficient operation at 1500 P.S.I.

Everyone is finding *Precision Dyna-seals* the simple answer to many sealing problems. *No grooves*—all you need is a flat surface to seal under bolt heads, rivet heads, cap nuts, flanges, special fittings, etc. Suitable for service with petroleum products, water, many other fluids and gases. *Precision* engineers will help you — and proper deliveries will keep your production lines going. Please send us your inquiries now.

FREE—*Write for your personal copy of our Dyna-seal engineering data booklet.*

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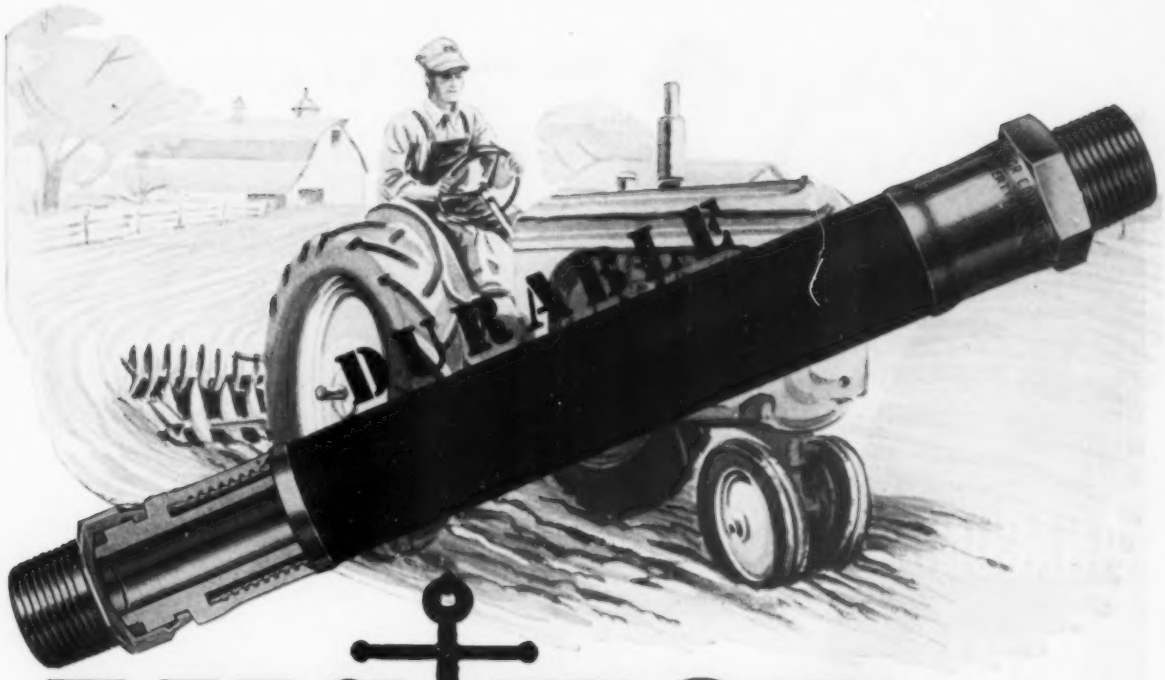

ANCHOR

ONE-WIRE BRAID HOSE ASSEMBLIES

for medium-and low-pressure service

Factory-assembled to your specifications—you get just what you need.

Long, uniform, positive grip assured by internally-threaded coupling shell.

Eliminates leaks and blow-offs in medium- and low-pressure service.

Sizes and types for every application — available with solid male or union male ends.

"O" ring seals prevent leakage between swivel ends and the coupling body.

Use of swivel male ends eliminates need for adapter unions, reduces the number of joints, and lets hose assume normal position when pressure is applied to the line.

Exclusive Anchor Max-Flo coupling gives you the equivalent of unrestricted flow through the couplings.

NEW!
REVOLUTIONARY
ANCHOR FLANCO
SPLIT-FLANGE CLAMP
Positive leakproof connection without threaded joints. Bolt centers are located to distribute the forces evenly and prevent tilting of the clamp halves. Easy to assemble with small automotive-type wrench.

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Get more information. Attach coupon to your letterhead and mail today!

ANCHOR COUPLING CO. INC.

Main Office and Factory: LIBERTYVILLE, ILLINOIS

FACTORY BRANCHES: DETROIT, MICHIGAN • DALLAS, TEXAS

Anchor Coupling Co. Inc.
Dept. PE93, Libertyville, Illinois

Yes, I'm interested in

- ☐ Anchor one-wire braid hose assemblies
- ☐ New Anchor Flanco Split-flange clamp-type coupling

Send me information.

Name..... Title.....

Company Name.....

Company Address.....

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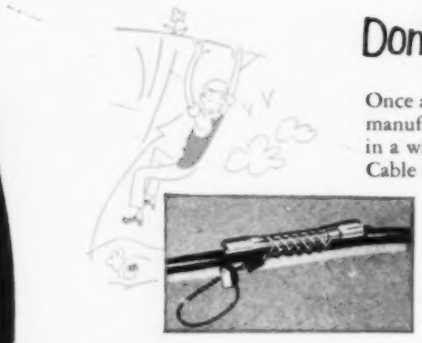
ANACONDA METALS AT WORK

Meet the educated screw

This is a whole family of screws, known as Screwsticks, and joined head-to-toe. Insert a Screwstick in the driver, aim it at the hole—and from there on the Screwstick tightens itself to the predetermined torque, shears itself and gets its head burnished by the following screw which automatically advances itself. It's so fast that American Screw Co. of Willimantic, Conn., which uses ANACONDA Hexagon Brass Rod, refers to it as "jet propulsion".



Don't lose your grip

Once a novelty trick developed by the Chinese, the manufacture of these grips is now an industry. Made in a wide variety of styles and sizes by Economy Cable Grip Co. of Norwalk, Conn., they are used to anchor suspended electric power cables and to seize the end for pulling through ducts. The harder you pull, the tighter they grip. Needless to say, the ANACONDA Bronze Cable, Everdur* Rod and Copper Tube used in their manufacture never weaken from rust.

A fast delivery...with mustard

When baseball fans want their hot dogs, they want them fast—so Stainless Alloy Fabricators of Detroit built this "Double-Header" baseball park hot dog server. Its big capacity for hot dogs—and fast service—is its double bun warmer, one at each end, heated by copper water boilers. If the water runs dry, it's no strike-out. Boilers are made of phosphorized copper sheet with joints formed by fusing the edges with a Heliarc torch. No solder used, no seams to burn open.

How to treat a fracture

A fracture often means long uselessness—but that needn't be true of machinery. Usually braze welding can make it good as new and at a fraction of the time and cost of replacing it. This fractured cast iron conveyor drive sprocket, for example, would have taken two months to replace. The Universal Welding Co., Rochester, N. Y., repaired it in only 7 hours by braze-welding with ANACONDA-997 (Low Fuming) Bronze Welding Rod. Moral: don't count the patient out before consulting your welder.

There's more to this than meets the eye

In our Technical Department you will find a range of experience that covers the entire field of copper and copper-alloy applications in the metalworking industries. If you have a problem of metal selection, we are at your service. *The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.* *Reg. U. S. Pat. Off. 5391

ANACONDA® the name to remember in COPPER-BRASS-BRONZE

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Field Consultants on Oil Hydraulics

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As a result, these men are uniquely qualified to help you in making hydraulics more useful to you and your customers. Their services take many forms . . . from complete circuit design to helping get the "bugs" out of a prototype machine.

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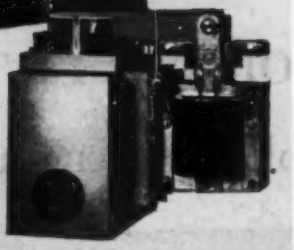
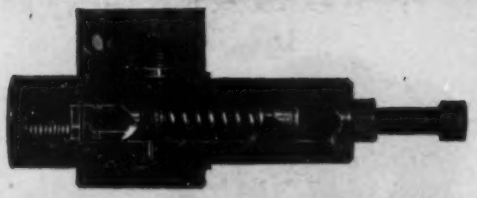
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

High Pressure
SOLENOID VALVES . . .



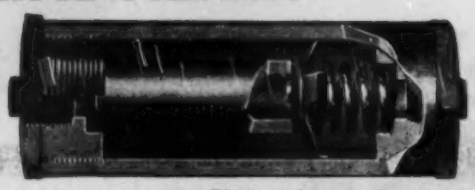
have working pressures range as high as 3000 psi. Specifically designed for remote push button control of hydraulic systems, as well as for the handling of any non-corrosive fluids. Poppet construction eliminates leakage. Impregnated coils are oil and moisture resistant. Unit can be mounted in any position. Available in 110-220 A.C.

ADJUSTABLE
FLOW REGULATORS



for cylinder speed control over a 50% range are built for pressures to 3000 psi. Model 320 shown meets requirements for cylinder speed adjustment yet maintains constant speed regardless of work or pressure fluctuations. There are types for Machine Tools—Earth Moving, Material Handling and Farm Equipment—Packaging Machinery—Steel and Paper Mills—Refineries—Printing Presses.

MICRONIC
LINE FILTERS



are made in pressures to 5000 psi for air, oil, water and other fluids. Compact—simple in design—have built-in durability—easy to clean. Micronic element filters to 40 Microns providing full protection for pumps, valves and cylinders. The elements, low in cost, are easily replaced. Make possible maximum flow with minimum pressure drop.

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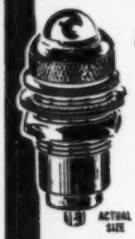
EVANSTON ILLINOIS

SUB-MINIATURE PILOT LIGHTS
Approved for AIRCRAFT
AND IMPROVED IN IMPORTANT DETAILS

DIALCO

A great aid to your miniaturization program

SUB-MINIATURE INDICATOR ASSEMBLIES



ACTUAL SIZE
NON-DIMMING
No. 8-1930-621

MOUNT IN 15/32" HOLE
ALL LENS COLORS

Easy lamp replacement with any midget flanged base lamp types

Complete blackout or semi-blackout dimmer types

ACTUAL SIZE
MECHANICAL DIMMER
No. 11-1930-621

THESE ASSEMBLIES LOGICALLY REPLACE LAMPS NO. 319, 320, and 321

PLASTIC PLATE (EDGE) LIGHT ASSEMBLIES

AIR FORCE and BUREAU of AERONAUTICS
MIL-L-7806 DRAWING MS-25010

DIALCO *No. TT-51* (Red filter-black top) or, *No. TT-51A*, complete with No. 327 Lamp

ALSO MADE
with other filter colors and with *light-emitting top* (for indication)

ALL OF THE ASSEMBLIES ILLUSTRATED ACCOMMODATE LAMPS NOS. 327, 328, 330, and 331.

ANY ASSEMBLY AVAILABLE COMPLETE WITH LAMP

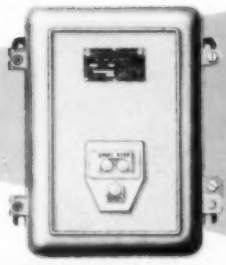
SAMPLES ON REQUEST — NO CHARGE

Foremost Manufacturer of Pilot Lights
DIALIGHT CORPORATION
60 STEWART AVENUE, BROOKLYN 37, N. Y. HYACINTH 7-7600

Fashion Note

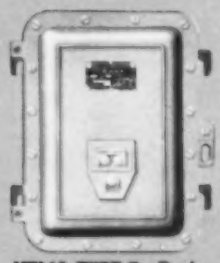
What the Well Dressed CLARK TYPE CY STARTER Will Wear in 1953

Type 1 Fabricated Steel, general purpose enclosure.



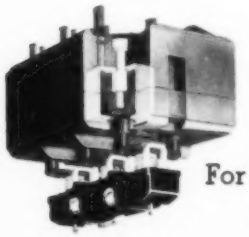
NEMA TYPE 9. Explosion resisting for hazardous dust locations. Cast iron enclosure.

NEMA TYPE 4. Watertight. Cast iron enclosures.



NEMA TYPE 7. Explosion resisting for hazardous gas locations. Cast iron enclosure.

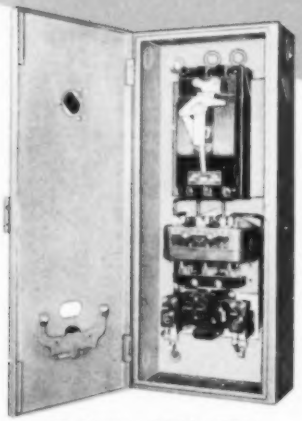
Type 5 Dust Tight, Fabricated Steel enclosures, with Gasket and Wing Nuts.



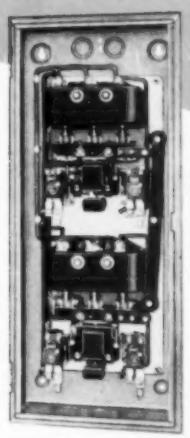
Cutaway View of Arc Box Showing Steel Encased Arc Chamber, Twin Blow-Out Coils and Contacts.

Style-wise, CLARK TYPE "CY" STARTERS are available in Sizes 0-1-2-3, in enclosures finished in Machine Tool Gray, set off by a piquant touch of Red, Yellow and Black on nameplates.

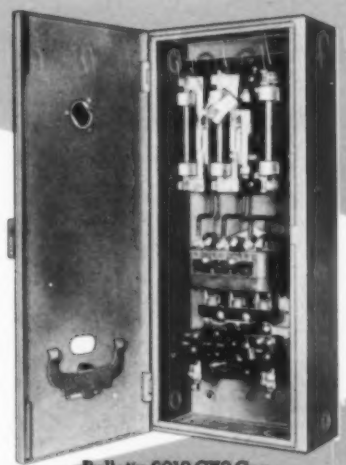
For every industrial atmosphere there's a fitting enclosure. Sizes 2 and 3 have the revolutionary arc quenching principle which combines strong multi-turn magnetic blow-outs with twin break contacts.



Bulletin 6020 CY2 Starter with air circuit breaker, in Safe-Edge Cabinet.



Bulletin 6050 CY2 Starter Two-speed double winding Consequent-pole starter in Safe-Edge Cabinet.



Bulletin 6018 CY2 Combination Starter with fusible safety switch, In Safe-Edge Cabinet.

Type 7 Cast Iron, explosion resisting enclosure for hazardous gas locations. A multi-speed starter.

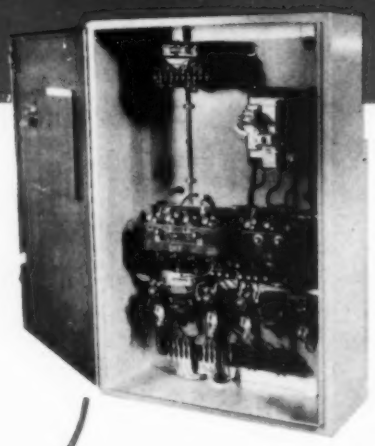
(B)

ENGINEERED ELECTRICAL CONTROL

THE CLARK CONTROLLER CO.

1146 EAST 152ND STREET, CLEVELAND 10, OHIO

CLARK TYPE CY

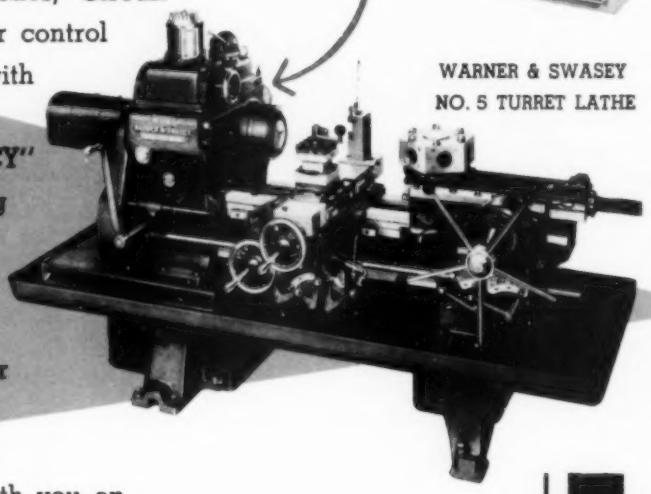


STARTERS and CONTACTORS

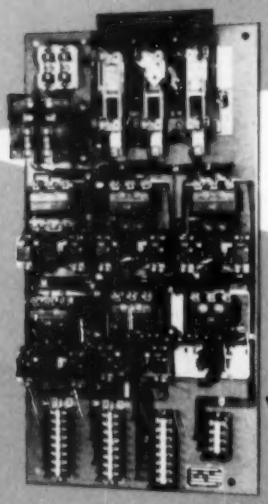
make ideal applications for machine tools

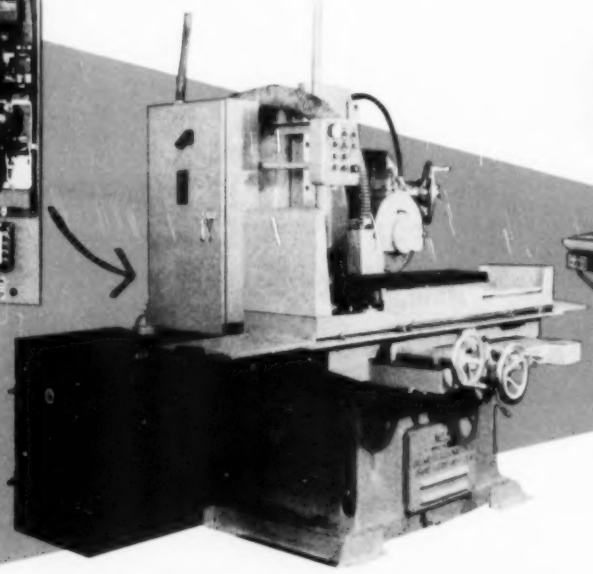
Clark Type "CY" Starters and Contactors are successfully combined with Relays, Disconnect Switches, Circuit Breakers, Transformers, Timers and other control devices to provide maximum service with minimum maintenance and downtime. Long contact life is provided by the famous "CY" Arc quenching principle, in which strong multi-turn magnetic blow-outs are combined with twin break contacts. Records of millions of operations with no noticeable contact wear are common.

Let Clark Application Engineers consult with you on your control problems.

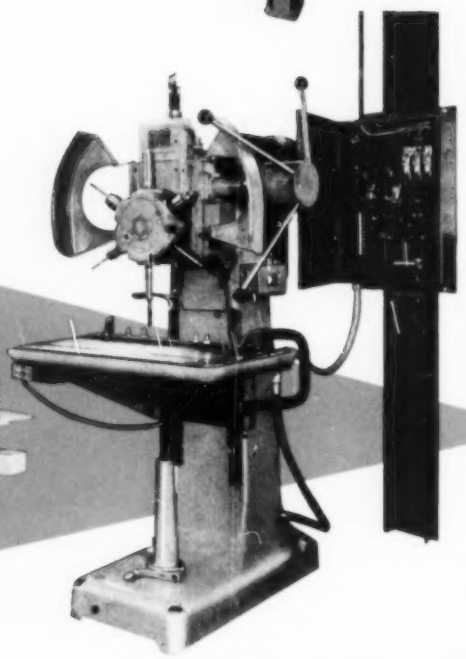


WARNER & SWASEY NO. 5 TURRET LATHE





GALLMEYER LIVINGSTON PRECISION GRINDER



BURMASTER TURRET DRILL

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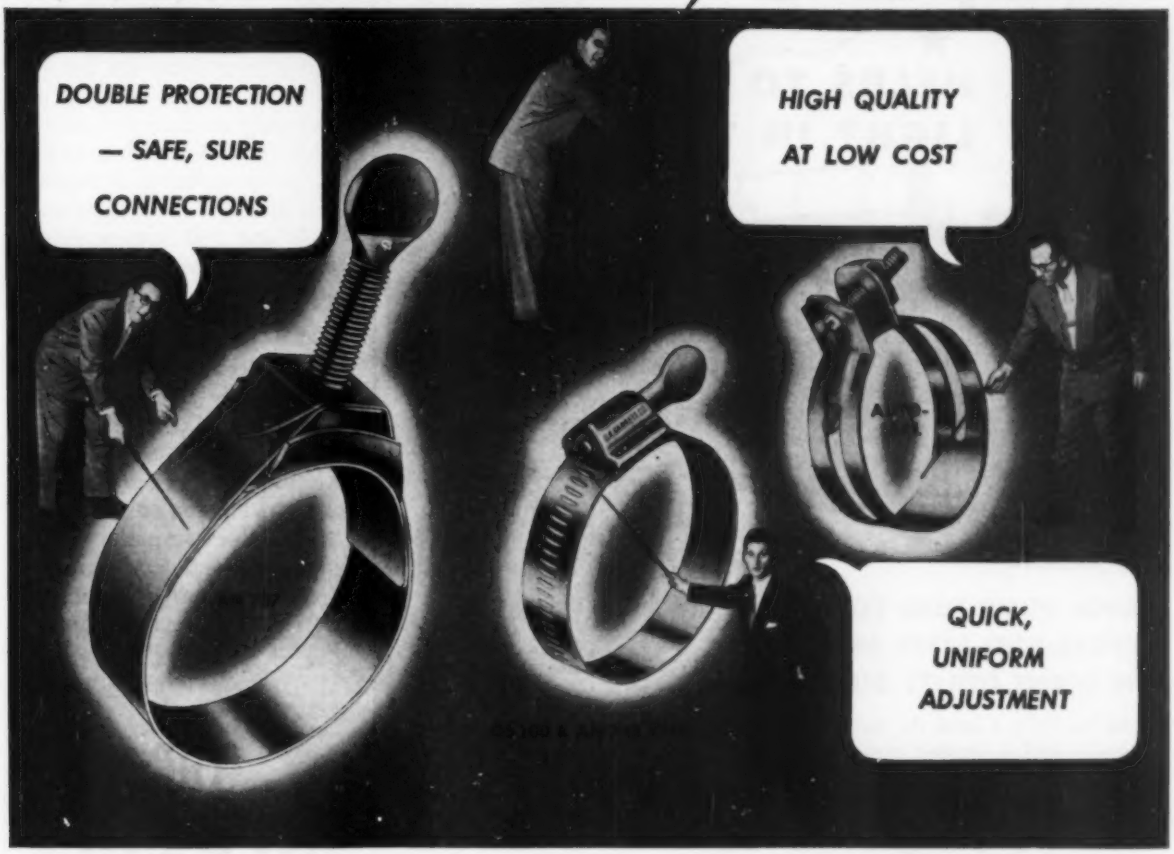

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AN 737 CLAMP—Approved for aircraft use by the Armed Forces. Stainless steel, radial type, with floating bridge and thumb screw adjustment. Mechanically fastened and spot-welded for double protection.

QS 100 & AN 748 TYPE—Worm type, self-locking screw assures uniform, instant adjustment. Plated to prevent corrosion. Used and approved by the Armed Forces.

AUTO-SEAL CLAMP — Screw-type adjustment, scarfed tongue prevents pinching. Staked bolt and captive nut prevents loss of parts. Rustproofed for long service.

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ROPER

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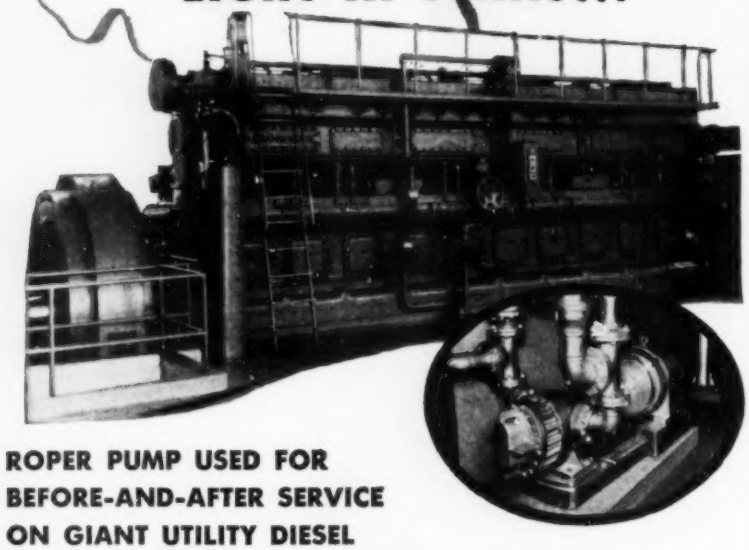
HELPS TO SHED SOME LIGHT IN TEXAS...



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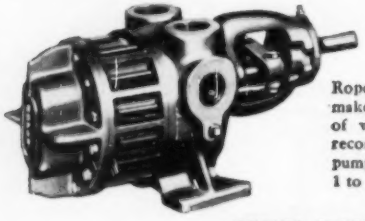
In big Texas, a small (by comparison) Roper 25F100 Pump with packed box is used to circulate lubricating oil for before and after operation on a big Fairbanks-Morse dual-fuel diesel. The operators of this Weatherford, Texas municipal power plant use a heavy duty, detergent oil for the lubricating system . . . the motor-driven Roper delivers this oil to bearings and (for cooling) to the pistons. Yes, Roper helps to shed some light and power in Texas . . . and Roper *dependability* is a very necessary quality in such an important installation.



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THESE techniques, although most closely associated with the industrial designer's needs, are also useful engineering tools. Their advantages and limitations, and the methods for transposing them into engineering drawings, are fully discussed and illustrated in our Special Editorial Report . . .

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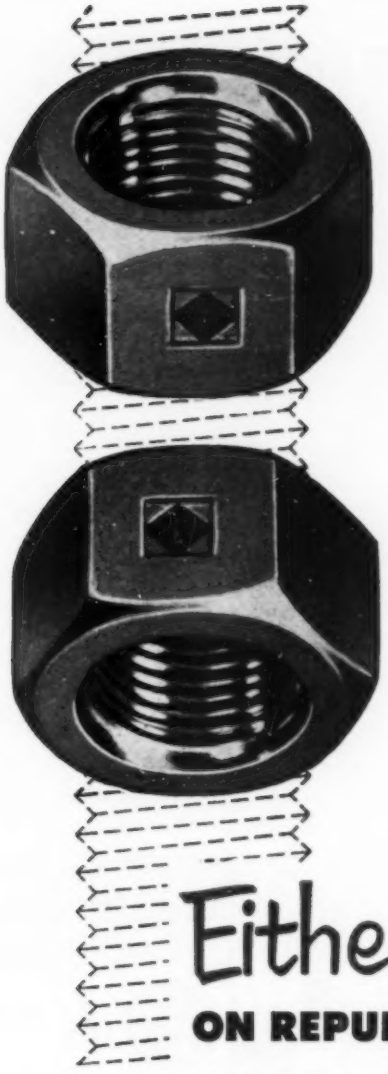

Either end is "UP"

ON REPUBLIC UPSON "NYLOK" NUTS

Here's an advantage that saves you man-hours and trouble on your assembly lines . . . no need to turn a Republic Upson "Nylok" Lock Nut end-for-end to get it right-side up. Screw them on either way . . . they go on easily, *stay* put even under severe vibration, and come off easily when you want them off. Ready to *re*-use, too.

Tell us the sizes you are interested in . . . we'll send samples of Republic Upson "Nylok" Nuts . . . the lock nut with the nylon pressure plug.

Light series tapped ¼" thru ¾"
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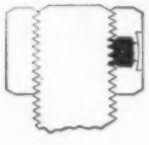
12 WAYS BETTER

Assemble from either end	No special tools
Can be re-used	One piece
Non-galling	Ideal for mechanical feeding
Best wrenching characteristics	No lubricant needed
Won't damage threads	Cold-forged
No special know-how	Lock in any position



Here's how the "Nylok" principle works

A nylon plug inserted in one of the sides of the cold-forged nut forces the nut tightly against the opposite threads as the nut is turned on.

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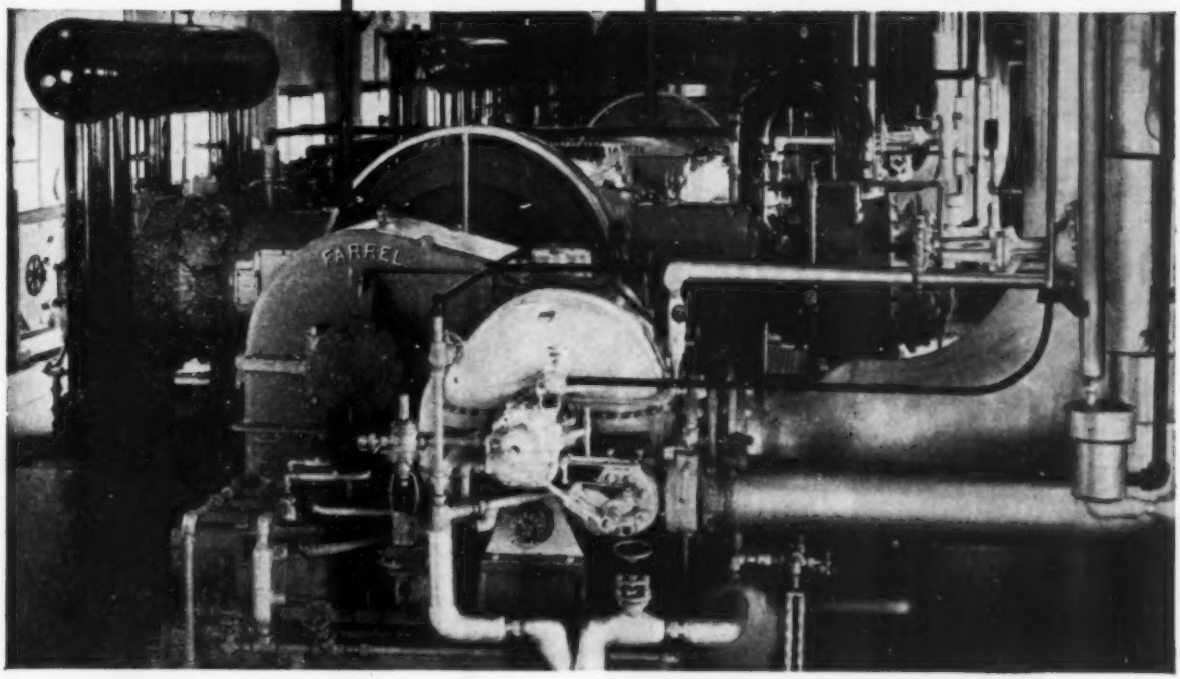

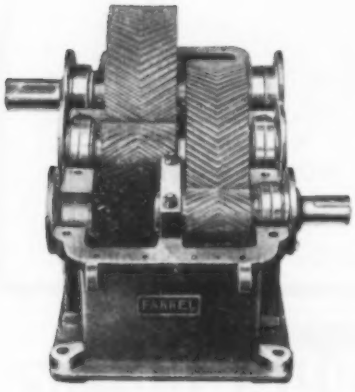

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Speed Queen Corporation, nationally-known home laundry equipment specialists use Durkee-Atwood V-Belts in their two newest products, the automatic washer and automatic clothes dryer.

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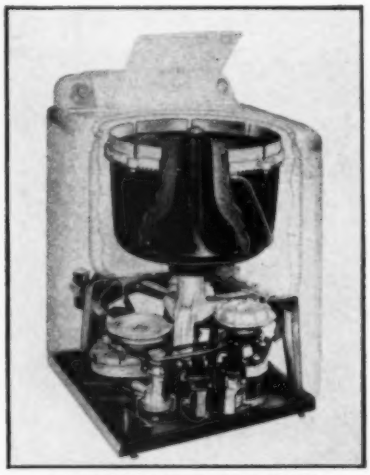
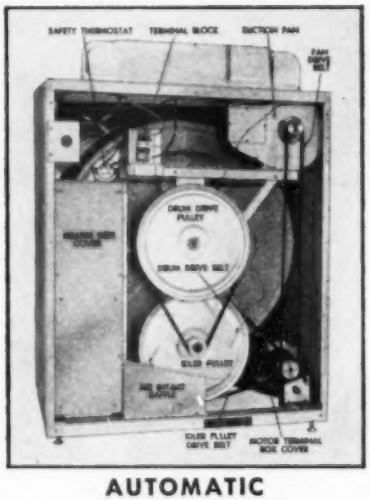


AUTOMATIC WASHER



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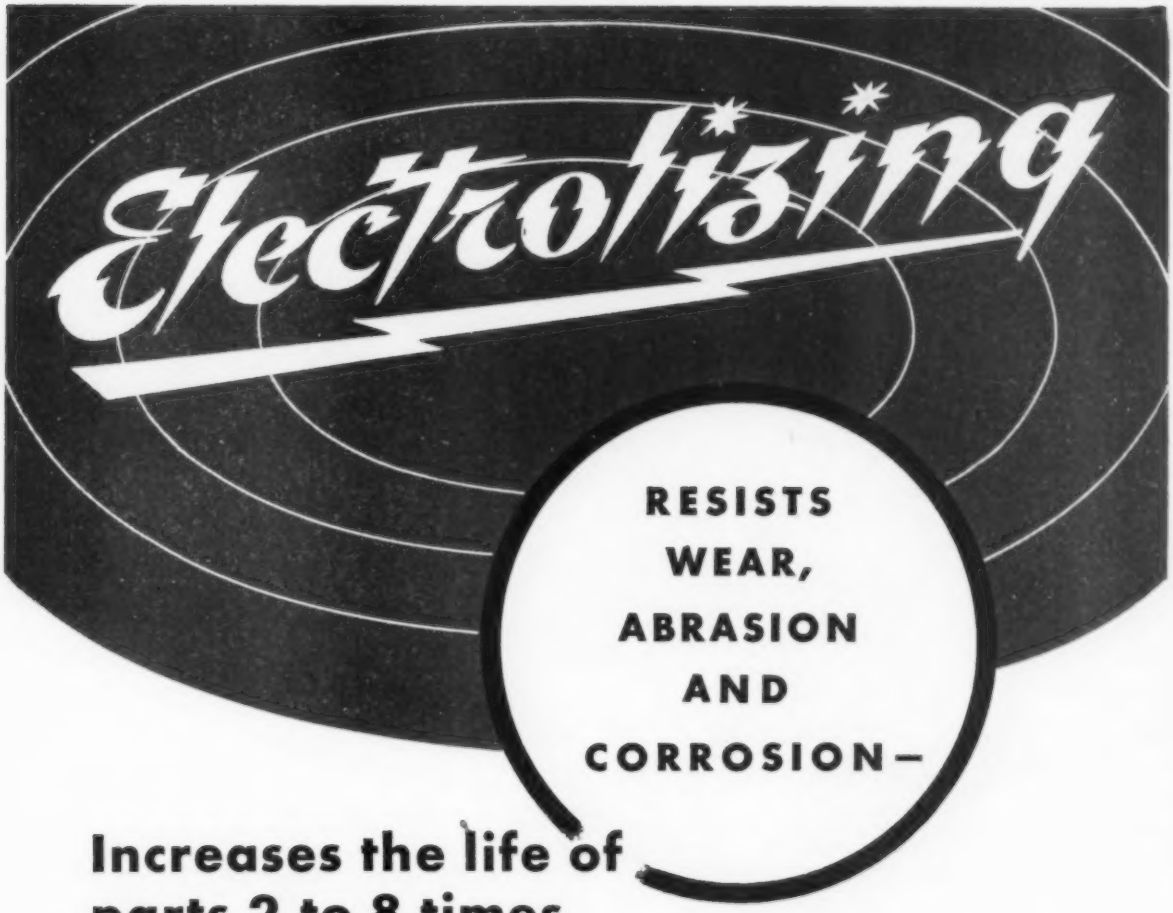

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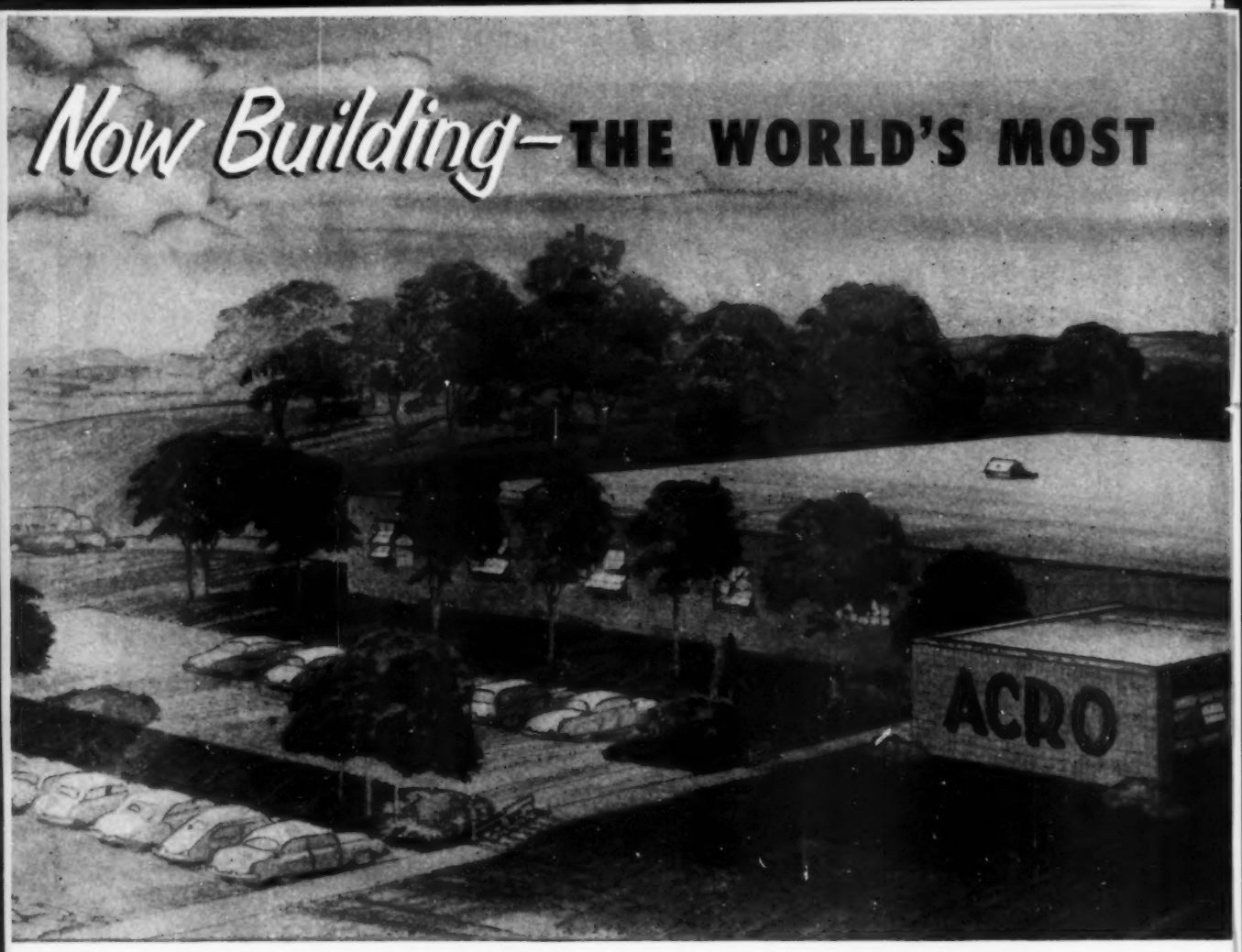

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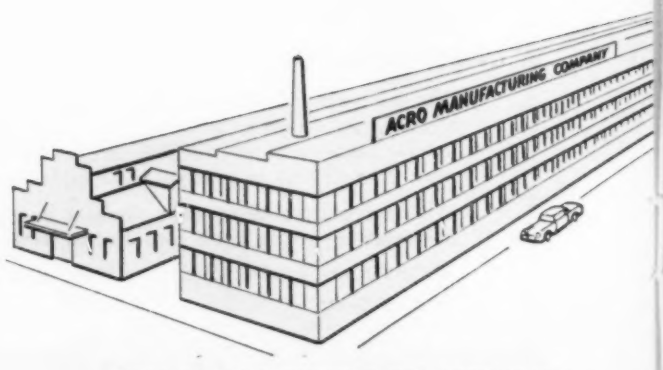
We will continue to manufacture certain lines of Acro and Mu switches at our recently modernized headquarters plant in Columbus, Ohio. At this location we also maintain our general offices, engineering department and research laboratories. Kindly address all inquiries, orders and correspondence to Acro Manufacturing Company, Columbus 16, Ohio.



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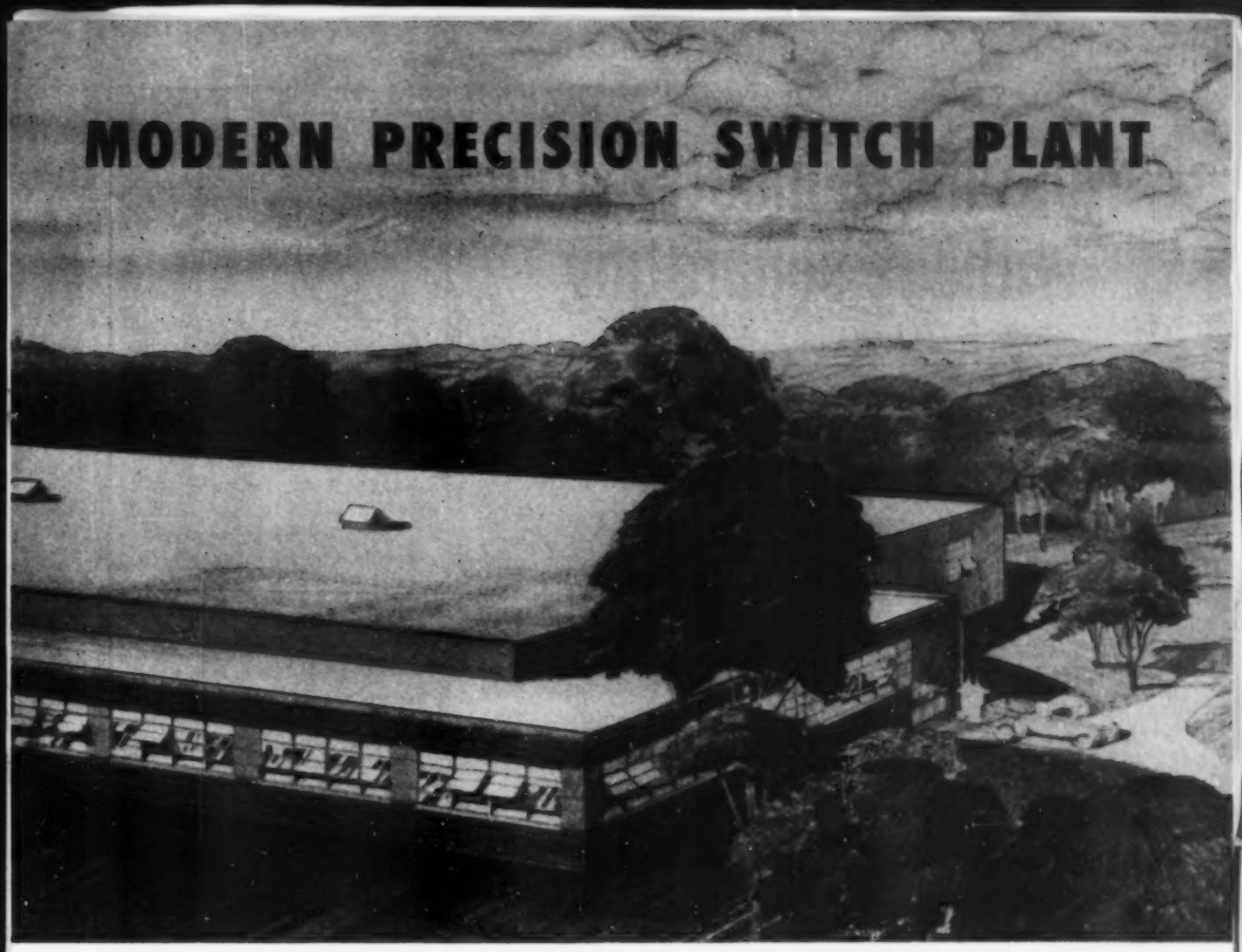

THIS HUGE EXPANSION PROGRAM MADE POSSIBLE BY YOUR EVER-INCREASING ACCEPTANCE OF ACRO SWITCHES AND MU SWITCHES

We are now building a sparkling new plant on a 14-acre site in Hillsboro, Ohio. When completed this Fall, it will be the most modern ever constructed for manufacturing miniature precision snap action switches.

All new equipment has been bought for our new Acro plant. This improved machinery, plus the latest in manufacturing techniques and methods, will enable us to produce even better Acro and Mu switches made to the highest precision standards.

This big, modern Hillsboro plant is our way of expressing appreciation to you, our customers, for an ever-growing volume of business. When ready, in a few short weeks, we will be able to quadruple our output.

Now, more than ever before, it will pay you to select and order from "The Biggest Line of Little Switches." There are over 7,000 standard specifications from which to choose. Our engineering and research staff will gladly work with you on special applications.

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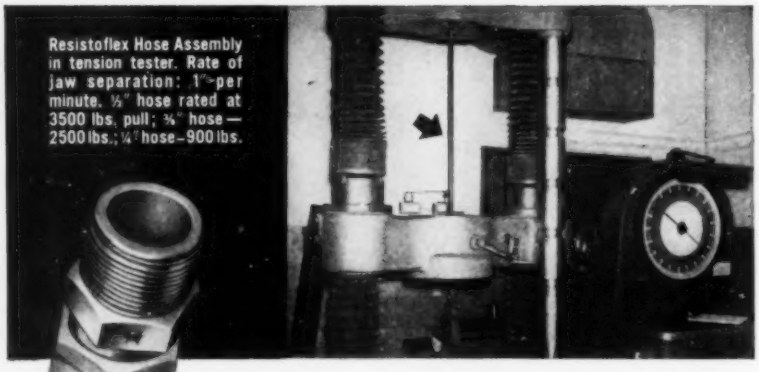
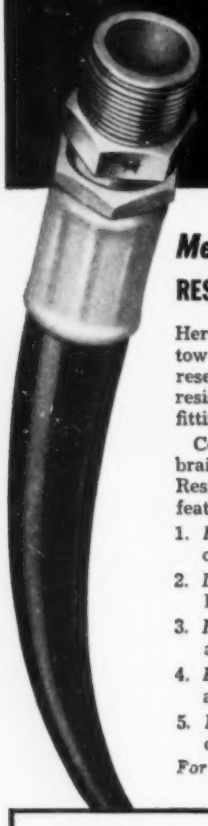
"THE BIGGEST LINE OF LITTLE SWITCHES"

Now... assemblies with extra pull strength...

withstand almost 2 tons without separating



Resistoflex Hose Assembly in tension tester. Rate of jaw separation: 1"-per minute. ½" hose rated at 3500 lbs. pull; ¾" hose—2500 lbs.; ¼" hose—900 lbs.



Medium-high working pressures also built into RESISTOFLEX INDUSTRIAL HYDRAULIC HOSE ASSEMBLIES

Here is a ½" hose assembly with enough pull strength to actually tow a trail-behind farm implement without snapping. This extra reserve proves two things. (1) The hose itself has the strength to resist hydraulic shocks and medium high pressures. (2) The fitting is on for good!

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4. *Full Flow at Fittings*—less than 5% reduction in cross section at crimp.
5. *No Gumming or Clogging*—compar hose liner inert to all hydraulic oils.

For more information, write for Data Sheet MH-1.

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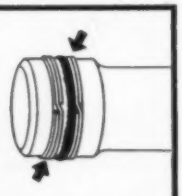
**Resistoflex Trade Mark*



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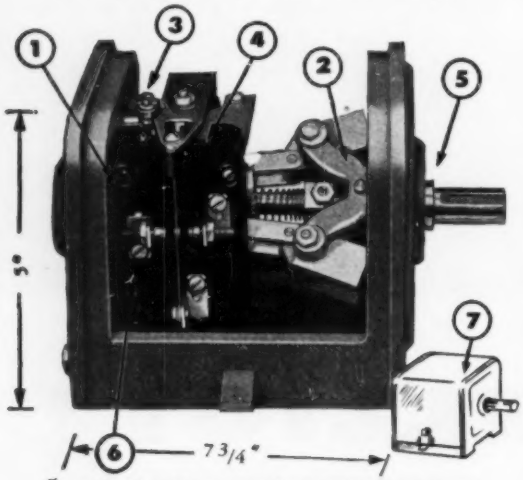

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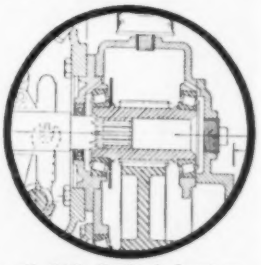

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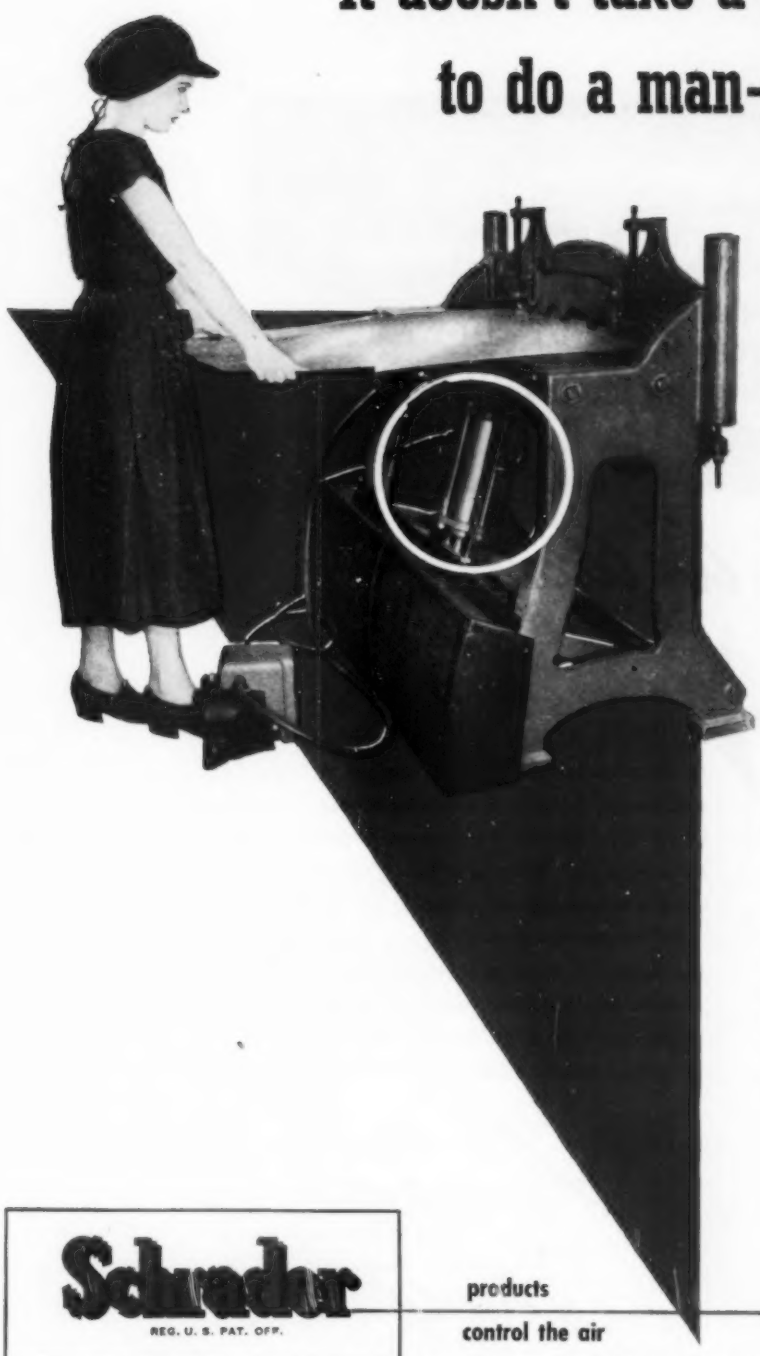

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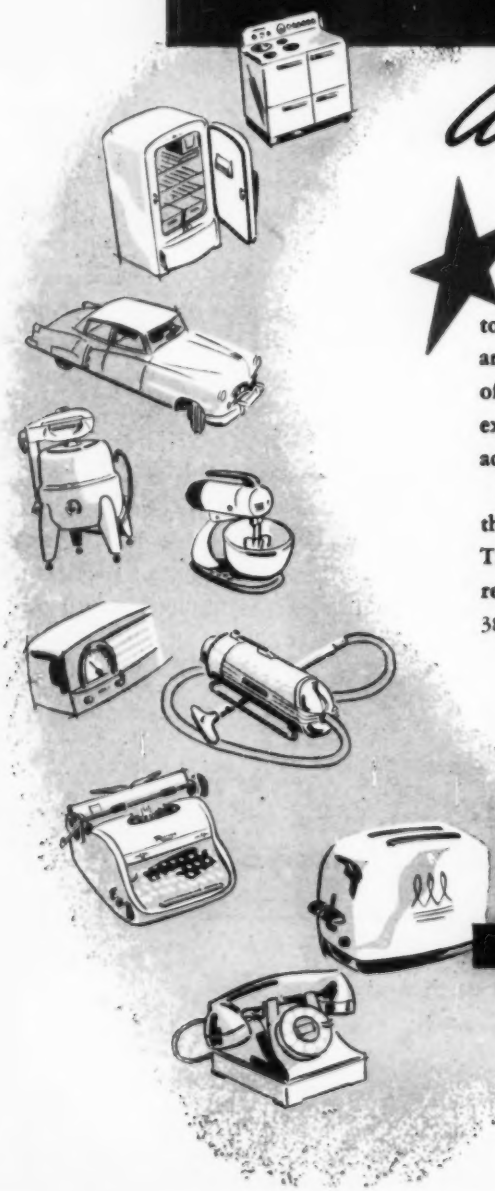

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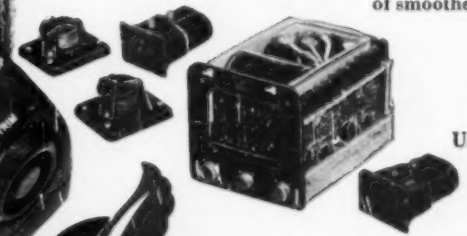

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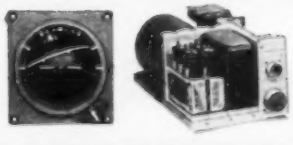

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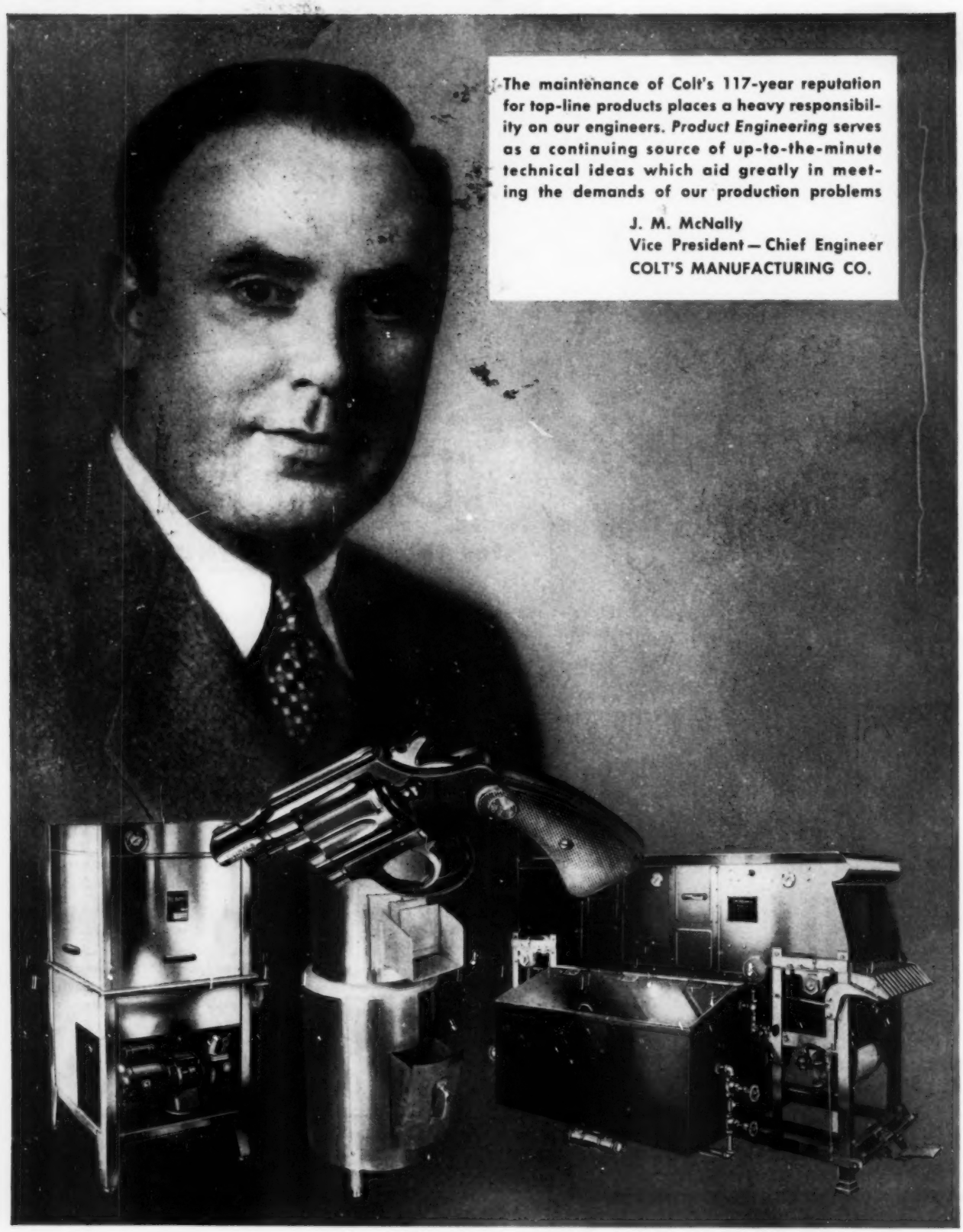
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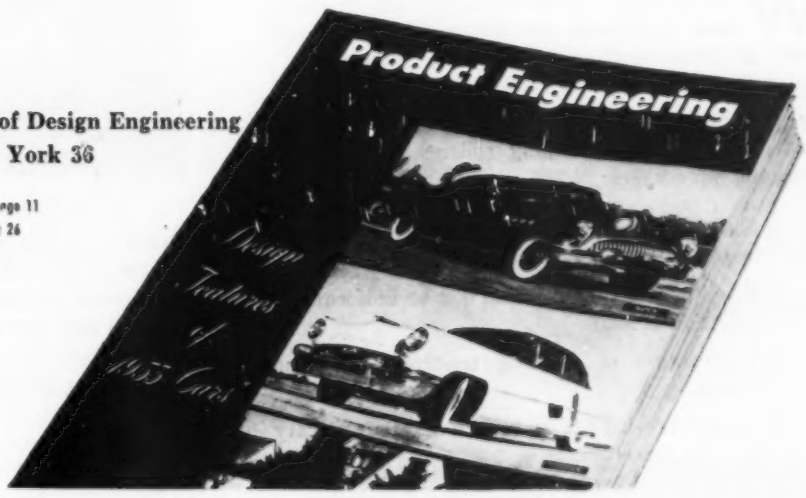

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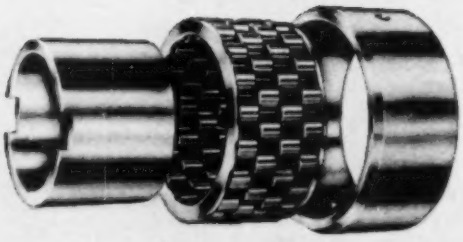
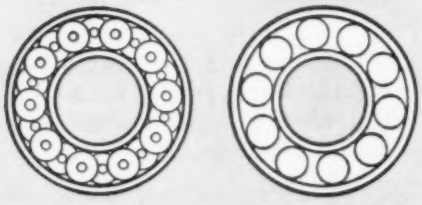


In Orange "Staggered" Roller Bearings the load is distributed over many short rollers, instead of a few full length rollers.



End views of a Staggered bearing and conventional bearing show how the staggered rollers provide a multiplicity of contact points within the loaded zone.

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Wherever radial loads are extremely heavy—operating conditions are unusually severe—and even, precision running is absolutely essential . . . install Orange "Staggered" Roller Bearings.

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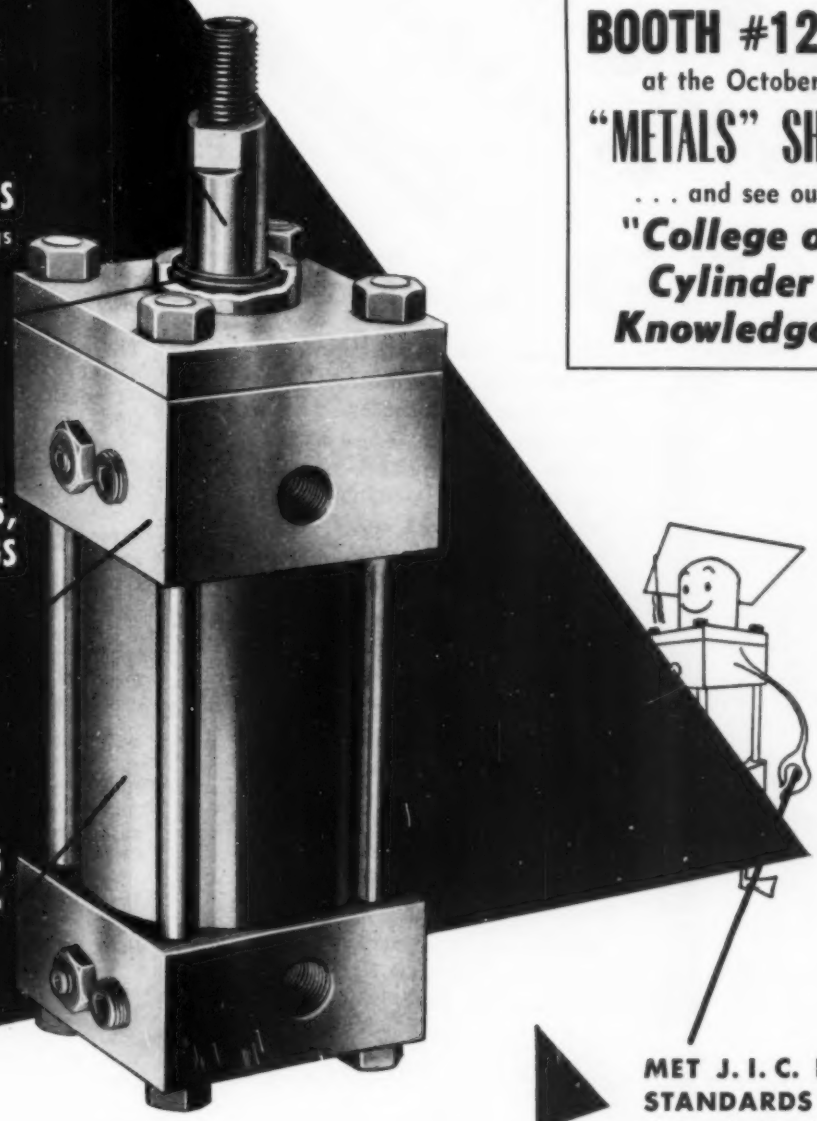

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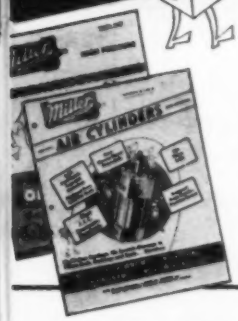

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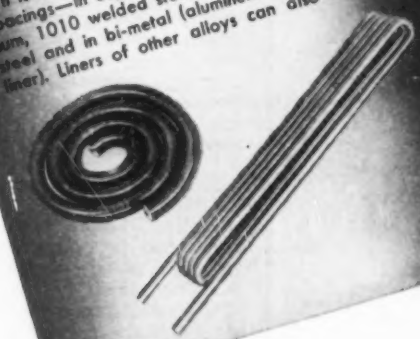

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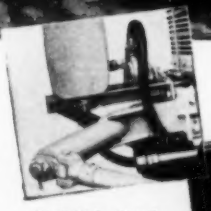
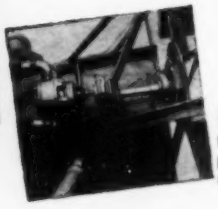


HYDRECO PUMP supplies hydraulic power

HYDRECO SELECTOR VALVE sets propeller in motion



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HYDRECO Oil Power, on the job for Adams, makes easy work of cutting snow banks down to size. A powerful HYDRECO fluid motor whirls a giant propeller that blows accumulated snow clear of the highway.

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What production problems are solved by each of these five processes used in making precision gears? What are the advantages of each process—what are the limitations?

An eleven-page report, fully illustrated by charts and photographs, examines these five gear-forming processes in detail in your *Annual HANDBOOK of Product Design for 1953.*

Your *Annual HANDBOOK* presents each year significant developments and useful data extending to virtually every subject area in the field of product-design engineering. The *HANDBOOK* is conveniently sectionalized into ten major subject classifications, enabling you to find exactly the information you want on any subject quickly. The report on gear-forming processes mentioned above, for example, is found in the section on *Fabrication and Production Processes.*

In November, you will receive the *HANDBOOK for 1954.* The new *HANDBOOK* will be even bigger and more informative than the tremendously popular *HANDBOOK for 1953.* And it's part of your regular subscription to *Product Engineering!*

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If your requirements involve the transmission of power in farm tractors, and if you are thinking in terms of performance, dependability and long service, it is more than likely you'll choose Clark Transmissions. They have been favored by automotive manufacturers for more than a quarter century . . . ample evidence, we believe, that "it's good business to do business with CLARK."
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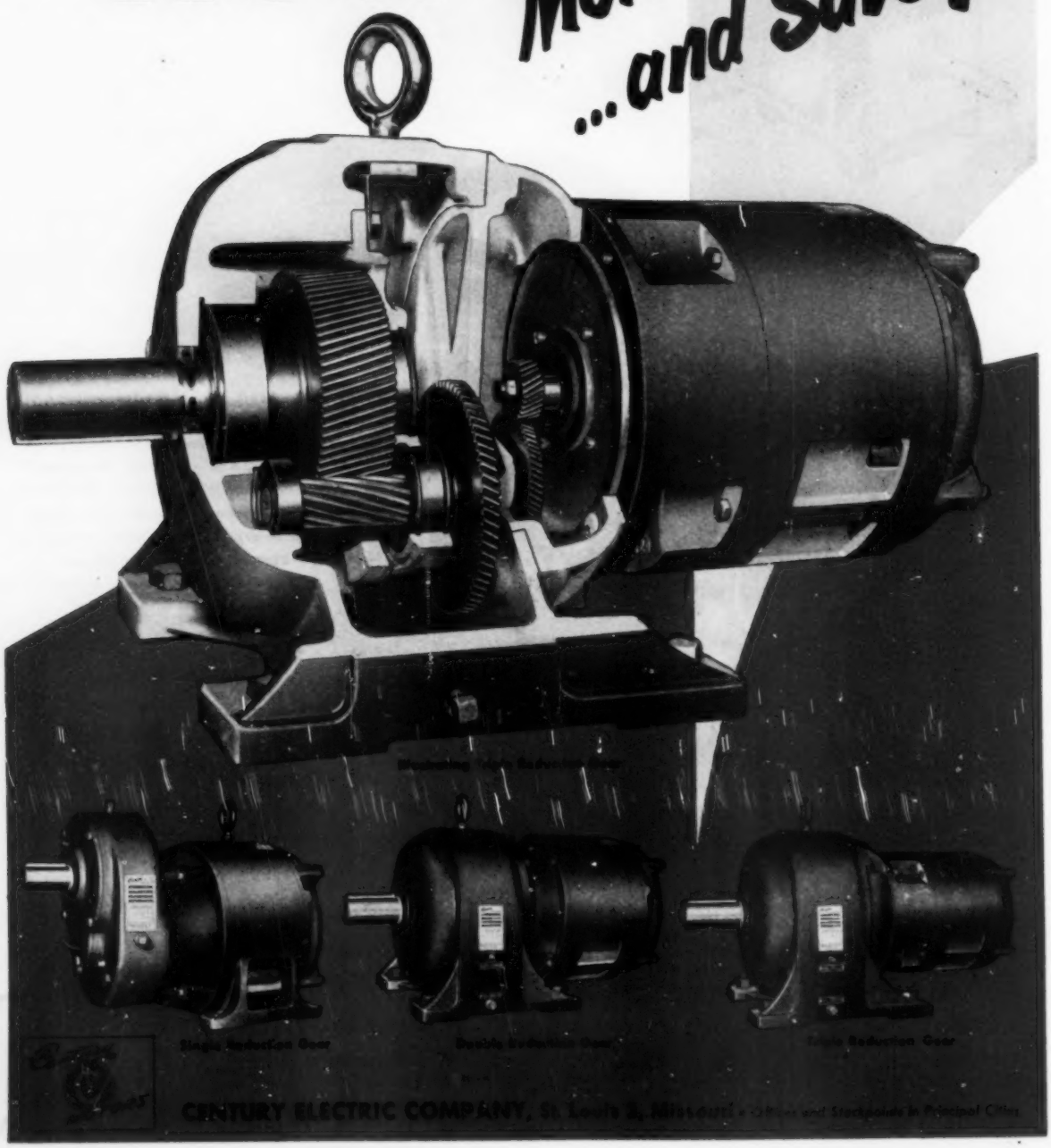

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Think of how you can improve power transmissions with more *compact drives* to save valuable space... *simpler drives* to minimize supplementary transmission ... *safer drives* with fewer exposed moving parts... *improved appearance* ... *smoother, more efficient operation*. *easier cleaning and maintenance.*

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- ***Open* type for normal conditions**
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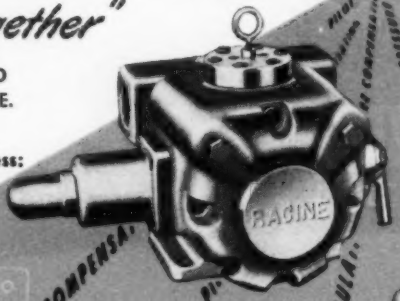

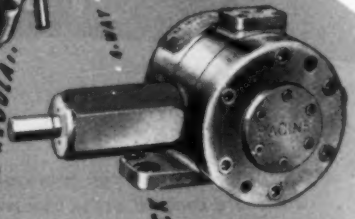

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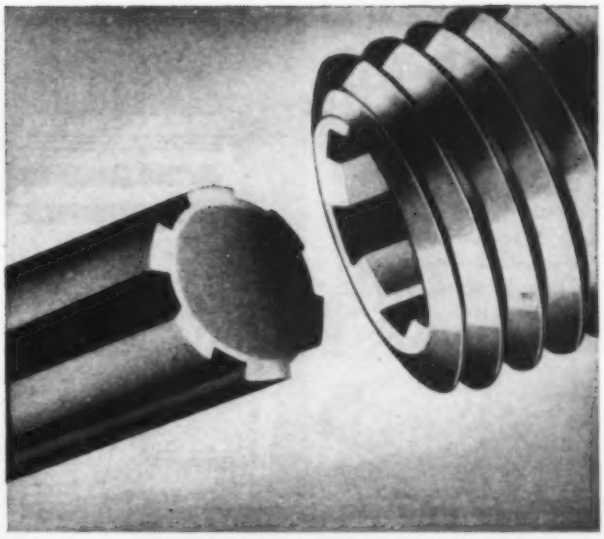
Multiple-Spline
SOCKET SCREWS

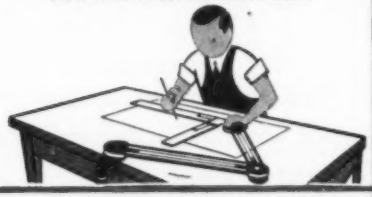
Stronger by far than any other kind!

The splining principle is recognized by design engineers as the best means of transmitting rotary power—that's why it's used in propeller hubs, in drive shafts and rear axles of automobiles. In Bristol's Multiple-Spline socket screws, this design results in strength and holding power not equalled by any other screw.



LOOK AT THE THINGS THEY DO . . .

FOR THE DESIGN ENGINEER



- ✔ **Tremendous holding power**
- ✔ **Withstand severe shock and vibration**
- ✔ **Permit neater, more compact design—fit flush, no projecting head**

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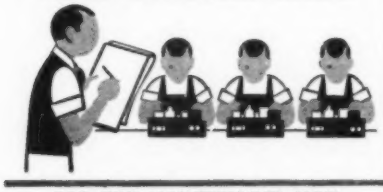

all the above, *plus* . . .

- ✔ **Greater holding power, permitting use of fewer, smaller screws.**
- ✔ **Will not round out, split or break**
- ✔ **Speed assembly—can be set tighter, easier, faster**
- ✔ **Minimize rejects and marring**

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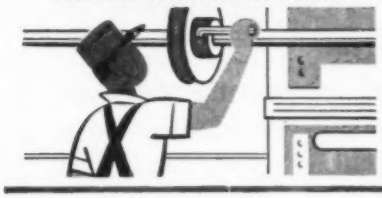

all the above, *plus* . . .

- ✔ **Can be tightened and loosened indefinitely**
- ✔ **Maintain desired set—won't shake loose**
- ✔ **Easily wrenched in hard-to-get-at places**
- ✔ **Tamper-proof**

Multiple-Spline Set Screw

Multiple-Spline Cap Screw

Bristol's Multiple-Spline Cap or Set screws are carefully designed to close tolerances (A.S.A. approved, Class 3 fit). Precision-threaded National Coarse or National Fine.

Materials: Standard and listed sizes stocked in heat-treated alloy steel. Brass, bronze, monel, stainless steel, etc., on special order.

Sizes: 0 wire to ½ in. in diameter.

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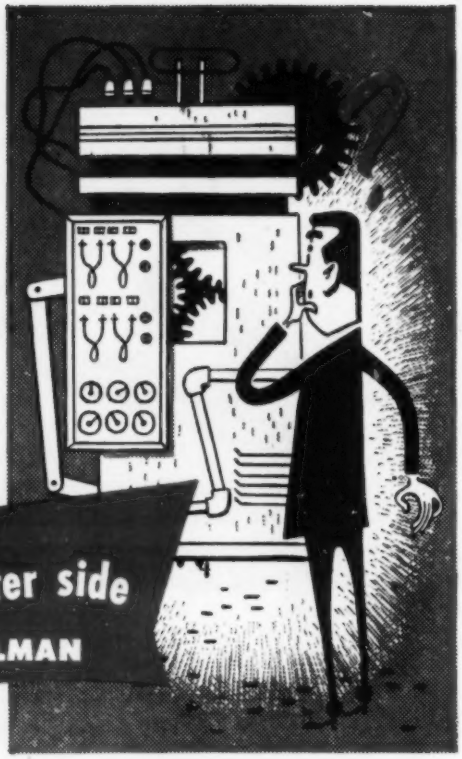
A.3.1

The freezer's automatic
The stove and TV too
The washer shuts itself off
Then starts itself anew

The car's a Mushomatic Eight
Remote controlled by knee
And who's in charge of all
this stuff?
Unautomatic me!



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on the lighter side
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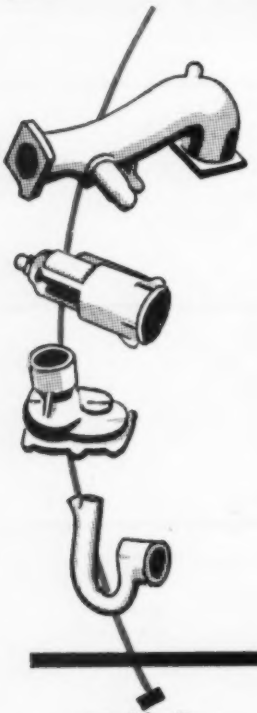

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So check the "New Catalogs and Bulletins" insert if you haven't already done so. You'll find a lot of useful information listed there . . . and any of it is available to you promptly and without cost.

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the new Totally-Enclosed Dual-Cooled motor

PATENT APPLIED FOR

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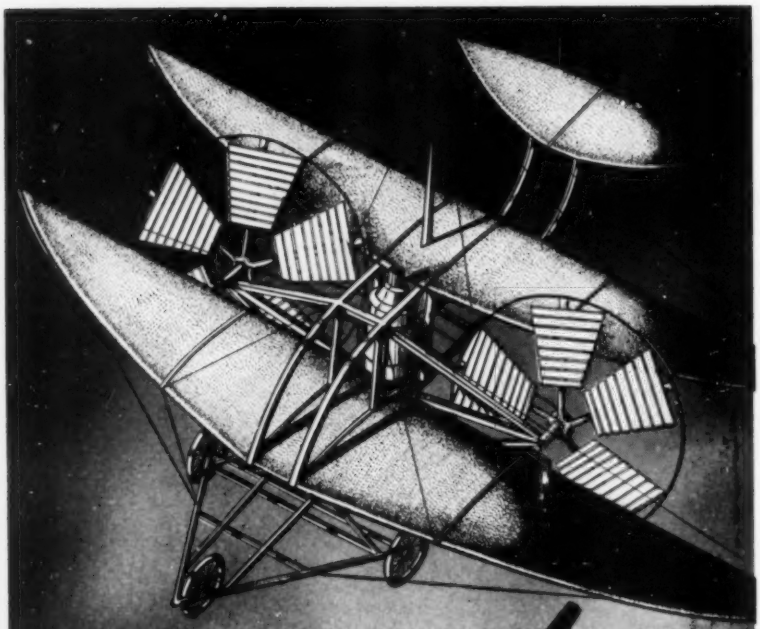

...out of this came Aviation

...a precision industry

To serve this great industry a manufacturer must maintain the best and most modern equipment available, operate it with skilled craftsmen, and use every existing method of tightening specifications and cutting production costs. Indiana Gear is such a manufacturer—a company of craftsmen producing fine quality transmissions and actuators for industry.

This is the control panel room in I. G. W.'s ultra modern heat-treating department—one of the contributing factors to Indiana Gear's unique ability to create hard-to-make parts to exacting specifications.

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Product Engineering

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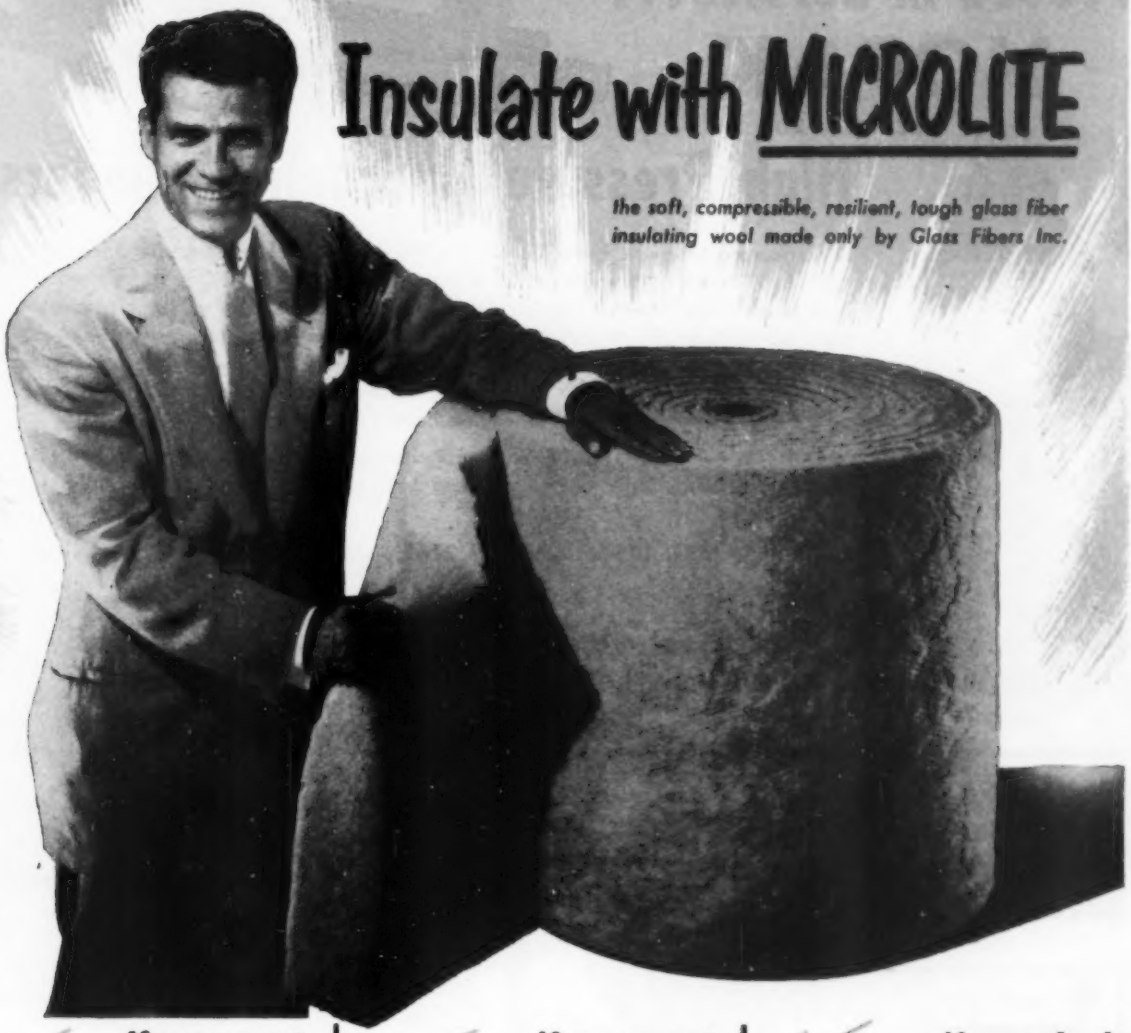
Insulate with MICROLITE

the soft, compressible, resilient, tough glass fiber insulating wool made only by Glass Fibers Inc.



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As an example, half-inch, half-pound density Microlite has a "k" value of .26 at 75° F. mean. If you want the greatest thermal or acoustical efficiency in the smallest space, insulate your product with Microlite. That's what designers of refrigerators, home freezers and house trailer coaches are doing. What's *your* space saving problem?

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As an example, 24 feet of half-inch, half-pound density Microlite weighs only 8 ounces. If you want the greatest thermal or acoustical efficiency with the least weight, insulate your product with Microlite. That's what designers of refrigerated truck trailers and aircraft are doing. What's *your* weight saving problem?

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Refer to Sweet's File for Product Designers or write for Bulletins HC-1 and SW-1.

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DESIGNED for AIR and HYDRAULIC SERVICE

Low-cost lock nut Saves 2 ways

1 *used as a load-carrying nut —offers triple locking action*

Provides vibration-proof assembly of light parts, without lockwashers. Three locking forces assure tightness (see cross-section). Has pleasing appearance of cap or acorn finishing nuts.

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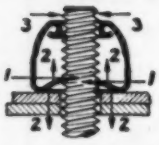
Holds any desired setting or position on screw thread. Locking force 3 (see cross-section) holds PALNUT in position with six powerful spring jaws which grip outside of screw.



- *Triple locking action holds tight under vibration*
- *Fast assembly*
- *Light weight*

Send details of application for free samples and catalog showing full line of PALNUT Lock Nuts.

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A Bronze as Strong as Nickel Steel

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Grade of HY-TEN-SL	1AA	1A	1	2	3	4
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Ultimate tensile strength lbs. per sq. in.				(Minimums)		
Sand Cast	125,000	115,000	108,000	100,000	90,000	85,000
Rolled 1" and under	.....	120,000	110,000	105,000	95,000	85,000
Rolled or Forged, over 1"	.....	115,000	108,000	100,000	90,000	85,000
Yield Point (divider method)						
Sand Cast	95,000	75,000	60,000	55,000	45,000	40,000
Rolled 1" and under	.....	75,000	65,000	60,000	50,000	45,000
Rolled or Forged, over 1"	.....	75,000	65,000	60,000	50,000	45,000
Elongation in 2"—%						
Sand Cast	10	12	14	15	20	25
Forged or Rolled	.....	12	13		15	20
Reduction in area—%						
Sand Cast	.....	12	14	15	20	25
Forged or Rolled	.....	12	13		15	20
COMPRESSION						
Yield Point— lbs. per sq. in.	70,000	65,000	58,000	50,000	40,000	35,000
Permanent Set at 100,000 lbs. per sq. in. (max.)	.015	.020	.030	.050	.080	.125
Brinell hardness, No.	250	240	220	200	175	150

List of U. S. Government Specifications Covering HY-TEN-SL Bronze

ARMY
Forgings, Rolled Rod QQ-B-721 Class B
Castings...QQ-B-726 Class B and C

NAVY
Forgings and Rolled Rod 46B15d Class B
Castings, Aluminum-manganese Bronze 46B29

WATERTOWN and OTHER ARMY ARSENALS
Castings WXS-5
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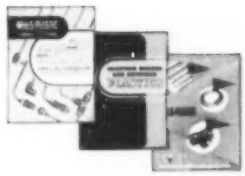
Let us show you today how our unique combination of sound engineering—*careful, correct* material selection and skillful molding can create a better plastic product for you.



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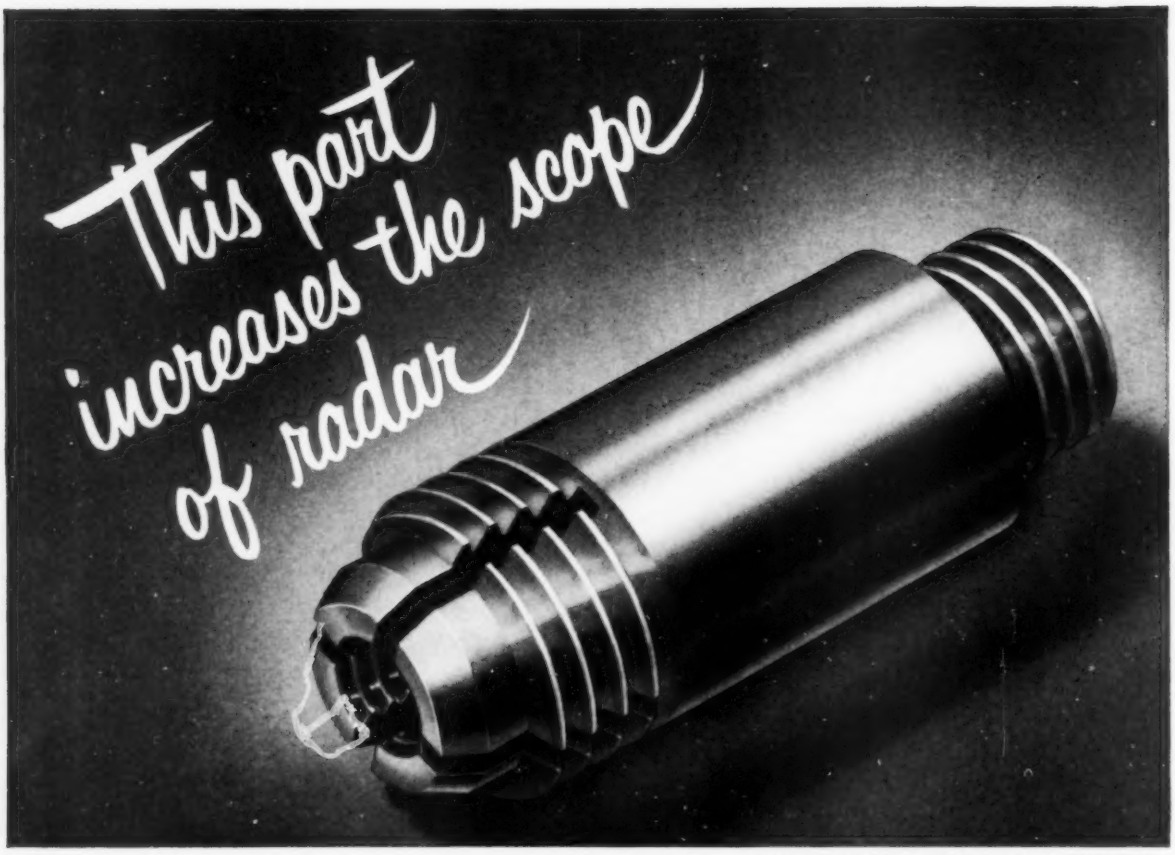

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IT'S MADE OF BERYLCO BERYLLIUM COPPER

This critical connector, used in new, improved radar devices, is made of Berylco beryllium copper for its many recognized advantages. Beryllium copper offers the designer desirable combinations of properties such as strength, spring action and formability in high degree.

As in all radar and electronic equipment, the material used for connectors, plugs, adapters, etc., must have current-carrying capacity. Berylco certainly has that. It must also retain firm contact pressure for a long time; it must be noncorrosive; it must be indifferent to wide temperature variations; it must not be subject to fatigue.

Berylco offers all these qualities to a superlative degree. For this particular part, which must be turned and threaded to close tolerance, machinability is important. In this respect beryllium copper offers special advantages through its age-hardening feature. This means that parts can be readily machined in a relatively soft condition and then hardened to give the desired combination of final properties.

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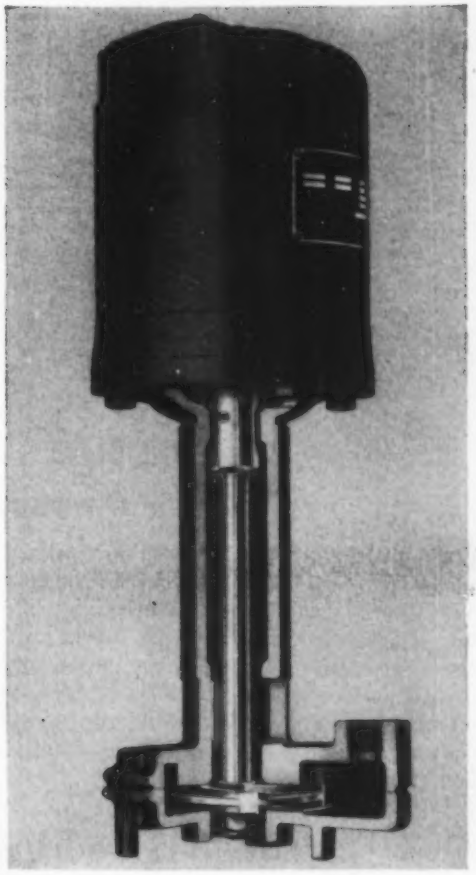
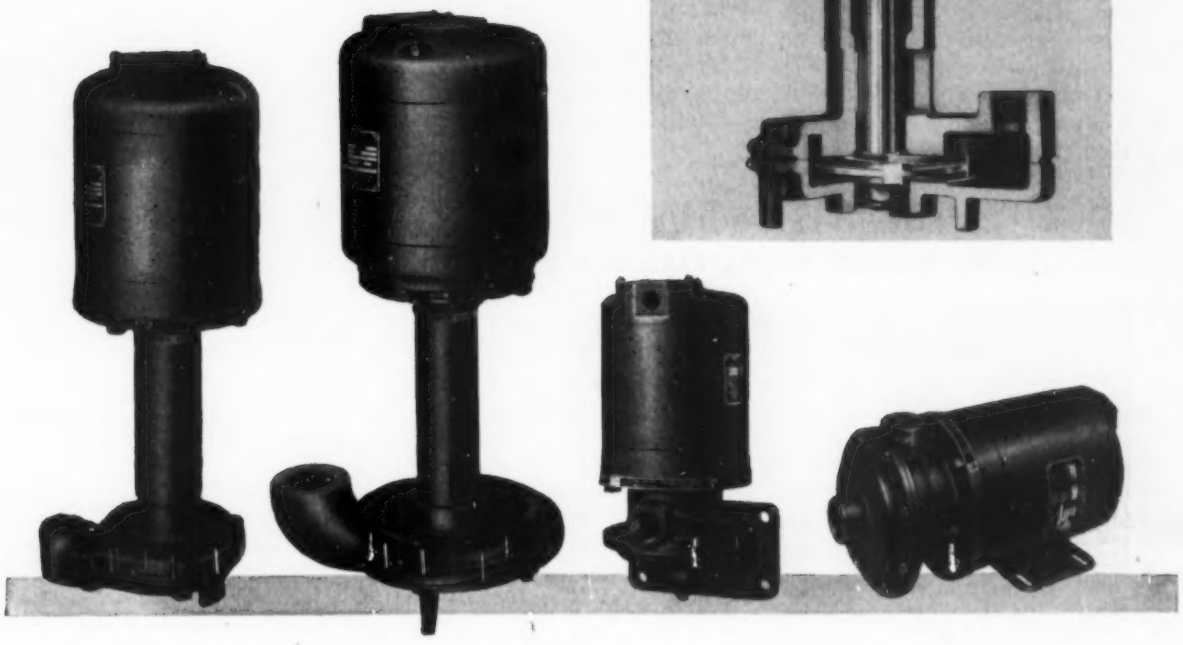
Motor-Driven Centrifugal Pumps That Dirt Can't Hurt!





Here's a complete line of ten different Motor-Driven Centrifugal Pumps that are completely protected from damage by dirt or abrasives. Hydraulically balanced, their design provides stability without using a bearing at impeller end of shaft . . . eliminates metal-to-metal contact below water level. All motors are of standard NEMA design, for easy replacement, and totally enclosed against dust or vapor . . . no lubrication or maintenance required.

You'll find that the design simplicity and sound construction of these Brown & Sharpe Pumps makes them ideal for countless applications where grit or foreign substances may be present. Write for Pump Catalog. Brown & Sharpe Mfg. Co., Providence 1, R.I., U.S.A.

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B·S

Brown & Sharpe

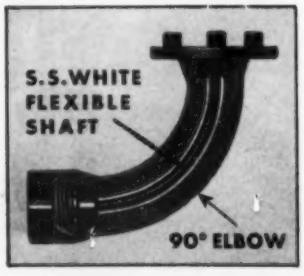
THE PROBLEM

TO MAKE A 90° TURN

A truck recording device, driven off the speedometer cable, had to be installed where it could be easily seen by the truck driver. The installation of the device made it necessary to provide a short 90° drive between the speedometer cable and the instrument. The original design called for a gear box to make the right angle coupling. This arrangement proved unsatisfactory, because the friction load imposed by the gear box and the recorder in cold weather caused a number of speedometer cable failures. As a result, the manufacturer chose —

THE LOW-COST SOLUTION

AN S.S.WHITE POWER DRIVE FLEXIBLE SHAFT



As the sketch shows, the flexible shaft, operating in a 90° elbow was a **simple, low-cost** way to do the job. In fact, since adopting the flexible shaft, the manufacturer reports that complaints of broken speedometer cables have been negligible. Let S.S.White engineers show you how flexible shafts can cut costs on your own power drive applications. Chances are they'll be able to point out ways to save not only on maintenance costs, but on production, parts and assembly costs as well.

The Design Engineer's Bible —
This 256-page flexible shaft handbook has complete details on flexible shaft selection and application. Copy sent free if requested on your business letterhead.

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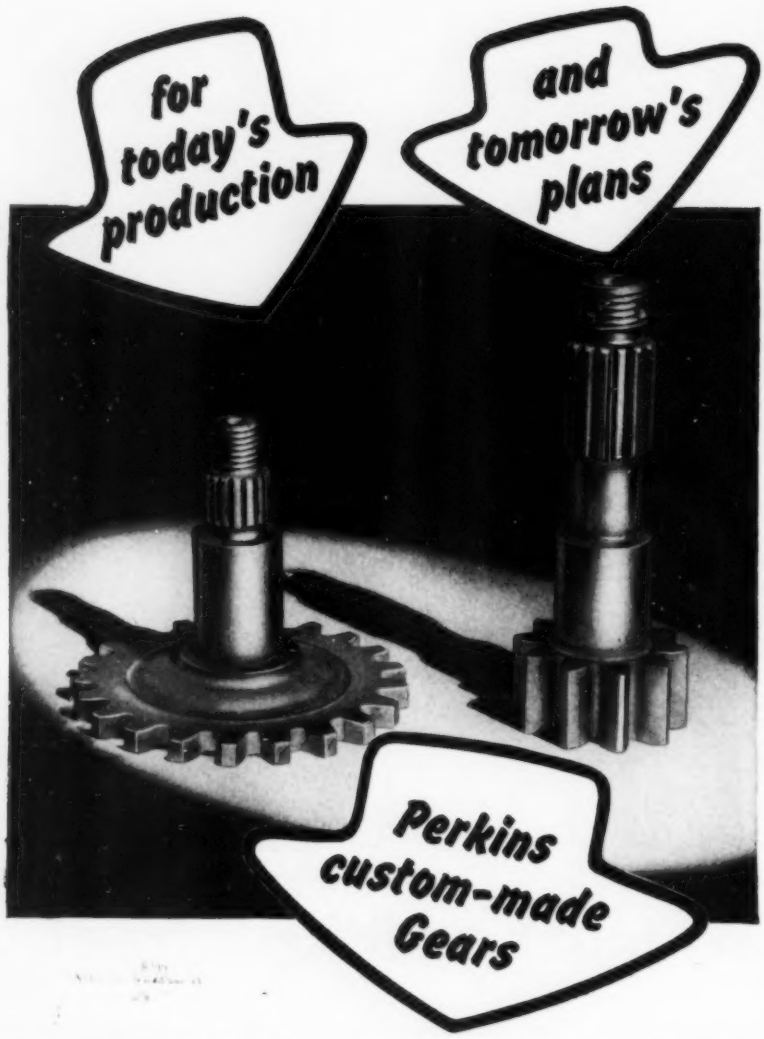

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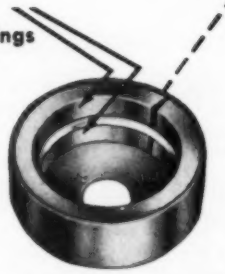

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Just as Stewart-Warner did, so you, too, can place your confidence in INDIANA for quality permanent magnets . . . for skill in manufacture . . . for cost-cutting engineering aid. Rigorous quality control in every step of production is your assurance of exact magnetic and physical characteristics. For help with your problem, write INDIANA, today.

PERMANENT MAGNETS MAY DO IT BETTER

DESIGN SUMMARY

Equipment—Electric Tachometer, manufactured by Stewart-Warner Corp., Chicago.

Application—Permanent magnet assembly.

Problem—To design a permanent magnet which would produce sufficient torque and give added stability to this instrument.

Solution—By varying the analysis and heat treatment, INDIANA engineers developed a special Cunife permanent magnet which provided the necessary torque and improved stability. Furthermore, this special Cunife magnet lent itself better to the limited space resulting from the new design.

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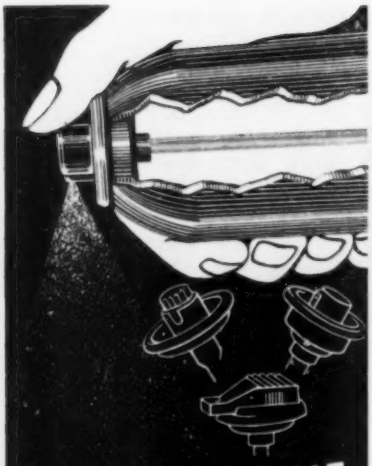
THE INDIANA STEEL PRODUCTS COMPANY • **VALPARAISO, INDIANA**

WORLD'S LARGEST MANUFACTURER OF PERMANENT MAGNETS



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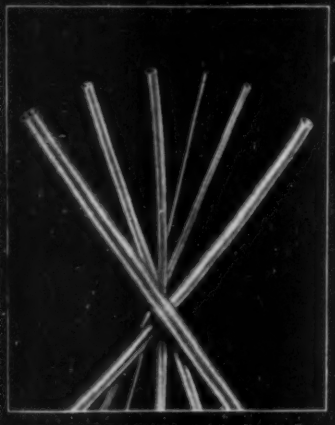

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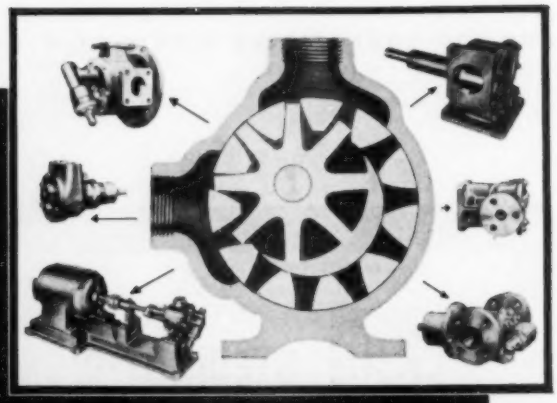

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PREPUNCHED TERMINAL MTG. CARD
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JUMPER STRIP Eliminates wiring for common circuits
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YOUR COMPLETED CIRCUITS FOR PLUG-IN PACKAGE OR CHASSIS

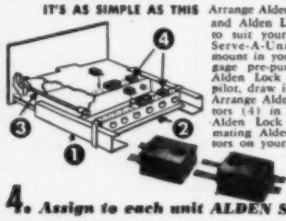
You can use Alden Terminal Mounting Card with Alden Miniature Terminals, Jumper Strip and Sockets staked to accommodate any circuitry—making complete units ready for housing. Components snap into unique Alden Terminals, are held ready for soldering.

2. To mount this vertical circuitry, ALDEN PLUG-IN PACKAGES AND CHASSIS give tremendous variety with standard components

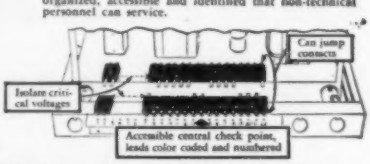
Alden components provide standard plug-in or slide-in housings—with spares, your circuits become units replaceable in 30 seconds.

3. Give chassis easily traceable interconnects and 30-second replacement with ALDEN SERVE-A-UNIT KIT

IT'S AS SIMPLE AS THIS Arrange Alden Side Rails (1) and Alden Lock Frame (2) to suit your chassis. Alden Serve-A-Unit Locks (3) mount in your chassis to engage pre-punched holes in Alden Lock Frame (2) to pilot, draw in, lock or eject. Arrange Alden Back Connectors (4) in orderly row on Alden Lock Frame. Mount mating Alden Back Connectors on your Chassis.



GIVING YOU 1) Chassis that plugs in, locks and ejects with half turn of the wrist. 2) Leads so beautifully organized, accessible and identified that non-technical personnel can service.



4. *Assign to each unit ALDEN SENSING ELEMENTS — to spot trouble instantly:*

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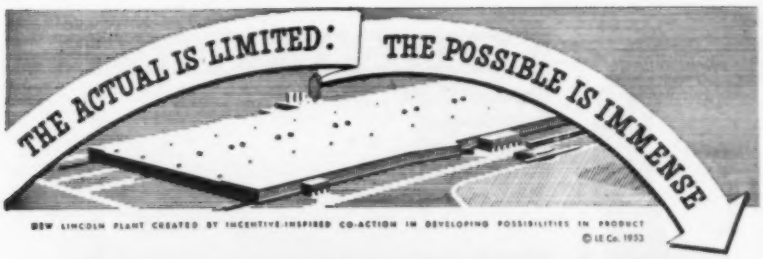
From Alden's Line of Ready-made Components for Unitized Plug-in Unit Construction


THE ACTUAL IS LIMITED:
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NEW LINCOLN PLANT CREATED BY INCENTIVE-INSPIRED CO-ACTION IN DEVELOPING POSSIBILITIES IN PRODUCT
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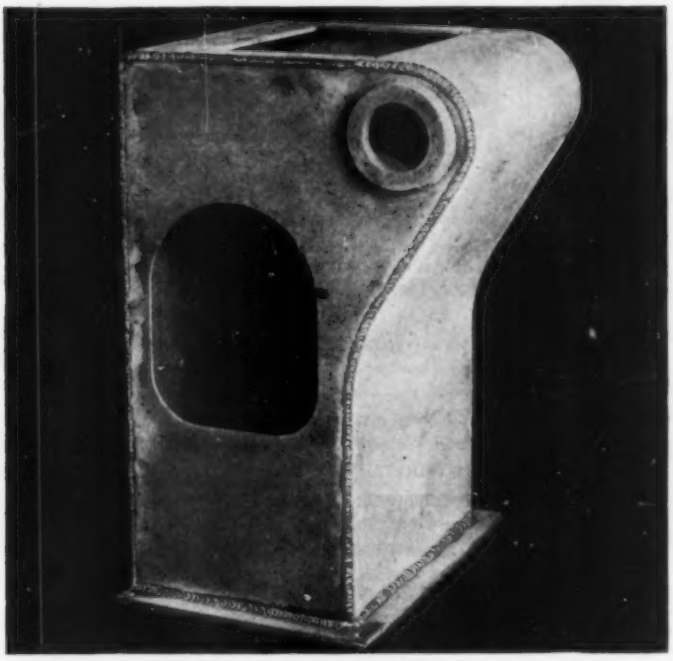

Fig. 3. Welded steel base *is made from ⅜", ½" and ⅝" plate. Flame-cut to shape, components are tack welded and then finished welded with fast down hand technique using "Fleetweld 7".*

WELDED LATHE DESIGNS CUT COSTS: SIMPLIFY PRODUCTION!

BY redesigning lathes for welded steel construction, Divine Bros. Co., Utica, N.Y. has cut excess weight from former cast bases and reduced manufacturing costs 24%. Eliminated investment in patterns.

With the present welded steel construction, less machining is required and costly storage and maintenance of patterns is eliminated, saving production man hours.

Of particular advantage is the shop's ability to alter or modify welded designs at low cost to suit special customer needs. Since pattern changes are no longer involved, production is simpler and deliveries are faster than possible with former cast designs.

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THE WORLD'S LARGEST MANUFACTURER OF ARC WELDING EQUIPMENT

ALL-WELDED DESIGN REDUCES COSTS CUTS MACHINING TIME

Fig. 1. All-welded construction *makes polishing and buffing lathe stronger, more rigid, yet cost of base has been cut from $107 to $86.*

REDUCES WEIGHT 15% SPEEDS PRODUCTION

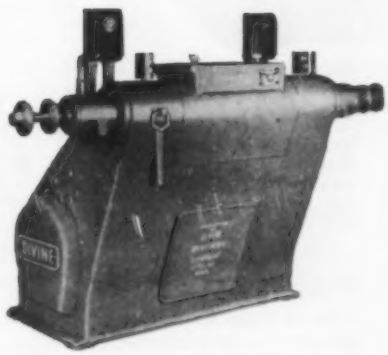
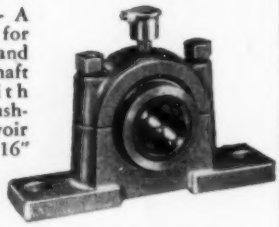


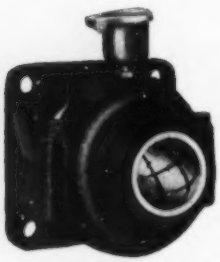
Fig. 2. Change to welded design *reduced weight of this lathe 328 pounds! Production no longer held up by delivery of castings.*

GET THE FACTS! **Latest ideas for speeding conversions from cast iron to welded steel construction are presented in Lincoln Bulletin, "Elements of Weldesign". Available to designers and production engineers by writing on your letterhead to Dept. 1305.**

THERE'S A RANDALL *PILLOW BLOCK* FOR EVERY TYPE *APPLICATION*

Normal Duty Pillow Block — A general service pillow block for normal duty on small shafts and for heavier duty on larger shaft sizes. Double-lubricated with graphited, phosphor bronze bushing in wool packed oil reservoir housing. For shafts ½" to 3 15/16" inclusive.





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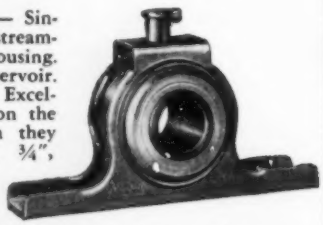
Sintered Bushing Series — Sintered bronze bushings in streamline one-piece steel housing. Wool packed oil reservoir. Mounts in any position. Excellent for general service on the smaller shafts for which they are available, ½", ⅝", ¾", 15/16" and 1".



Write for catalog No. 109.—For additional information on these as well as other one piece or two piece pillow blocks available for light, normal or heavy duty. There's a Randall Pillow Block for every type application.

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BRONZE BUSHINGS
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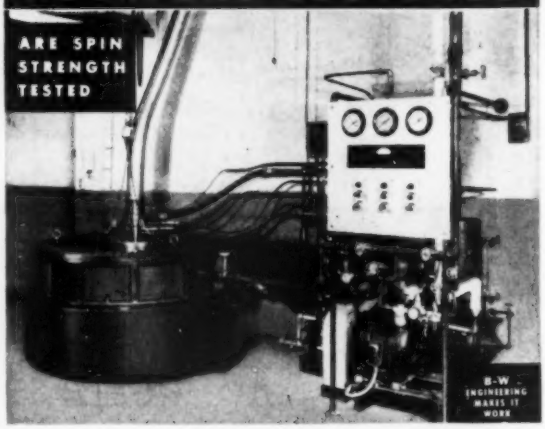
ROCKFORD CLUTCHES



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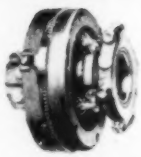

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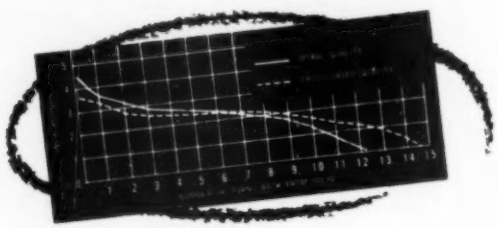

Graphic evidence of Power Spring superiority through *Crosscurving*

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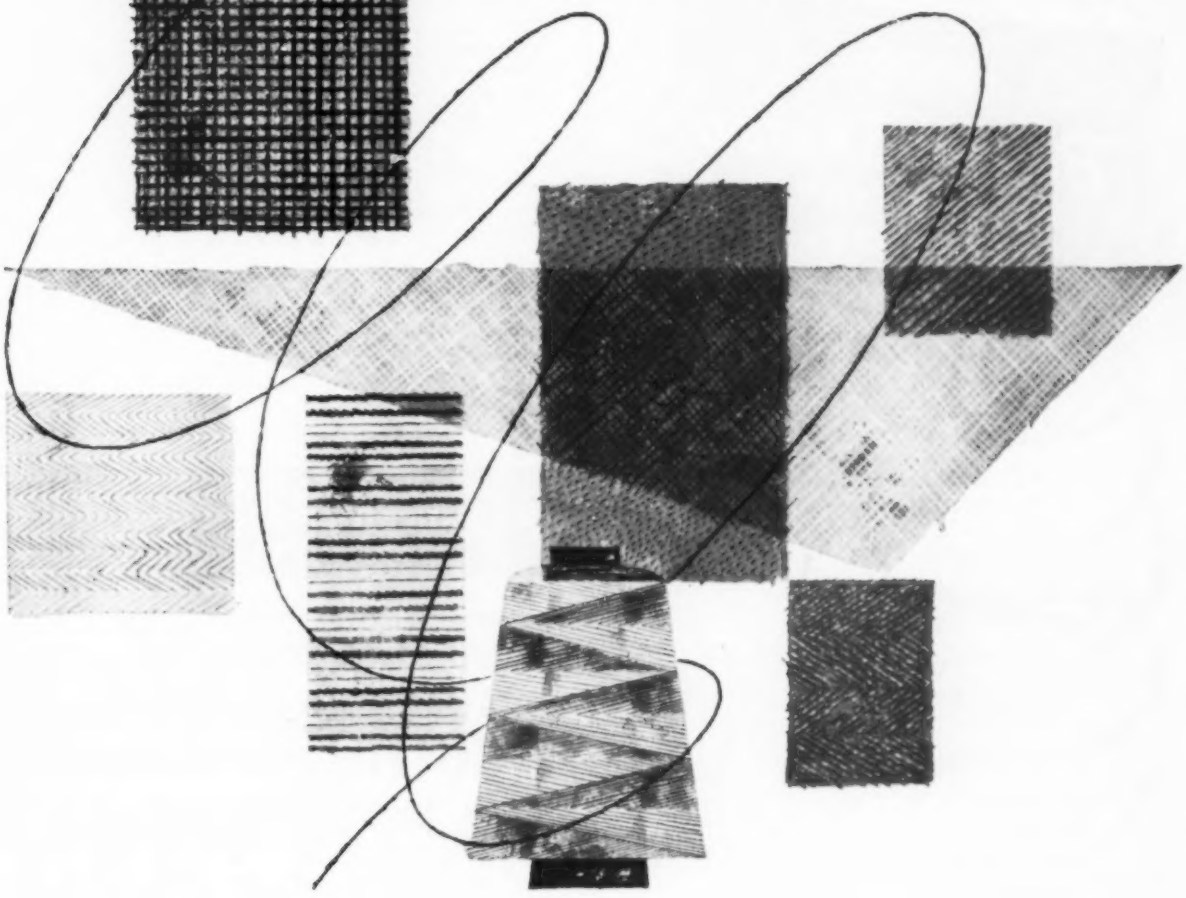
Helps make textile products

better, safer, lighter, stronger



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Pittsburgh Yarns have achieved a reputation for quality. Made in the nation's newest fiber glass plant, Pittsburgh Yarns are controlled to exceptionally uniform fiber diameters. This is an important factor in the manufacture of textile products to high standards. Our technical staff will be glad to furnish data and assistance with any fiber glass applications. Pittsburgh Plate Glass Company, Fiber Glass Division, 420 Fort Duquesne Boulevard, Pittsburgh 22, Pennsylvania. District Sales Offices: Chicago, Cincinnati, Cleveland, Detroit, New York, Washington.

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PITTSBURGH PLATE GLASS COMPANY

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Specify **Bendix-Skinner** RIBBON FILTER ELEMENTS . . .

- LOWER ORIGINAL COST
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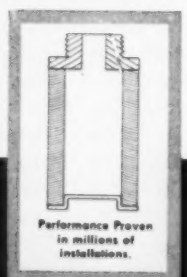

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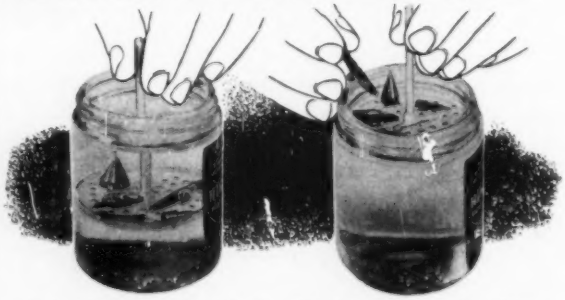

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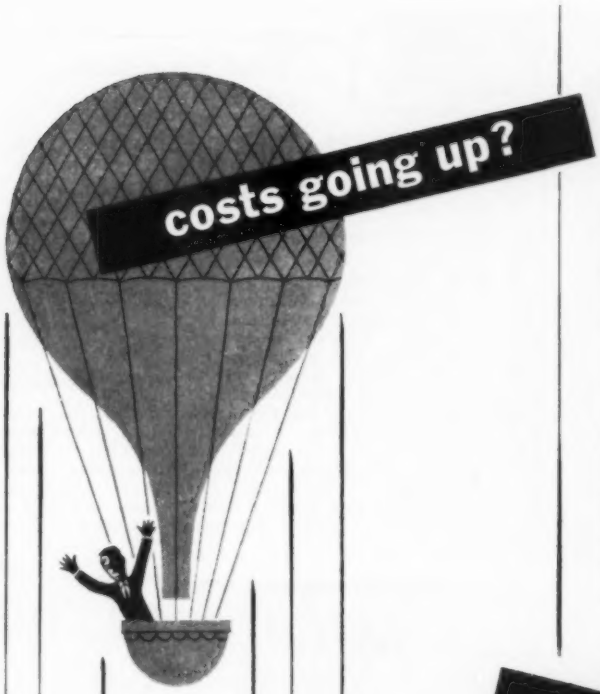

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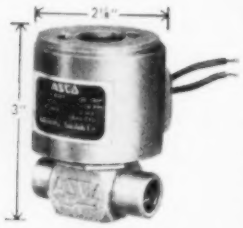

Bulletin 8262 Two-Way ASCO Solenoid Valves (Illustrated) can be obtained with by-pass and metering devices. Valves can be installed in any position. Bulletin 8314 Three-Way Valves can be applied to any 3-way valving requirement regardless of flow directions or pressure application points; no change of springs or other adjustments are necessary. These valves can also be mounted in any position and will give positive tight shut-off.

BULLETIN 8262

2-Way Valve (Normally Closed)**

(Available for all commercial and industrial voltages)

Body Material		Brass or Stainless Steel			
Pipe Sizes (inches)		1/8		1/4	
Orifice Diameters (inches)		1/16	1/8	5/32	3/16
Maximum Pressures lbs./sq. in.	A-C	300*	130	90	60
	D-C	250	70	50	30

*Available 1000 psi in stainless steel; 500 psi in brass.
**Also available normally opened.

BULLETIN 8314

3-Way Valve

(Available for all commercial and industrial voltages)

Body Material		Brass or Stainless Steel	
Pipe Size (inches)		1/8	
Orifice Diameters (inches)		3/64	3/32
Maximum Pressures lbs./sq. in.	A-C	125	45*
	D-C	50	25*

*Pressures slightly lower for liquids.

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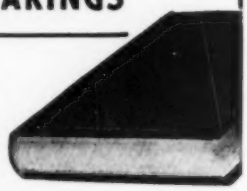
The DESIGN and PERFORMANCE of SHAFT BEARINGS



THIS new book, includes the latest developments and procedures in bearing analysis and lubrication. It discusses, first, the general principles of bearing load analysis, introducing dimensional analysis in order to generalize the results of bearing load computations. It then takes up the principles and problems of hydrodynamic lubrication . . . discusses rolling contact bearings . . . and considers the many variables of importance in boundary lubrication. A final chapter describes a representative group of bearing test machines. Throughout the book, the external conditions imposed upon representative shaft bearings have been considered in detail and integrated with lubrication theory.

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This new book's analysis of shaft bearings is divided, roughly, into external and internal phases. It considers the bearing in relation to its position in the mechanism, and studies the conditions imposed on the bearing by its surroundings. Attention is directed to the manner in which the bearing supports the applied load. Common practices used in the design of bearings are treated fully. The book discards those practices contrary to fundamental concepts, suggesting more logical criteria, and points the way to rational design procedures based upon sound principles and the results of controlled experiments.

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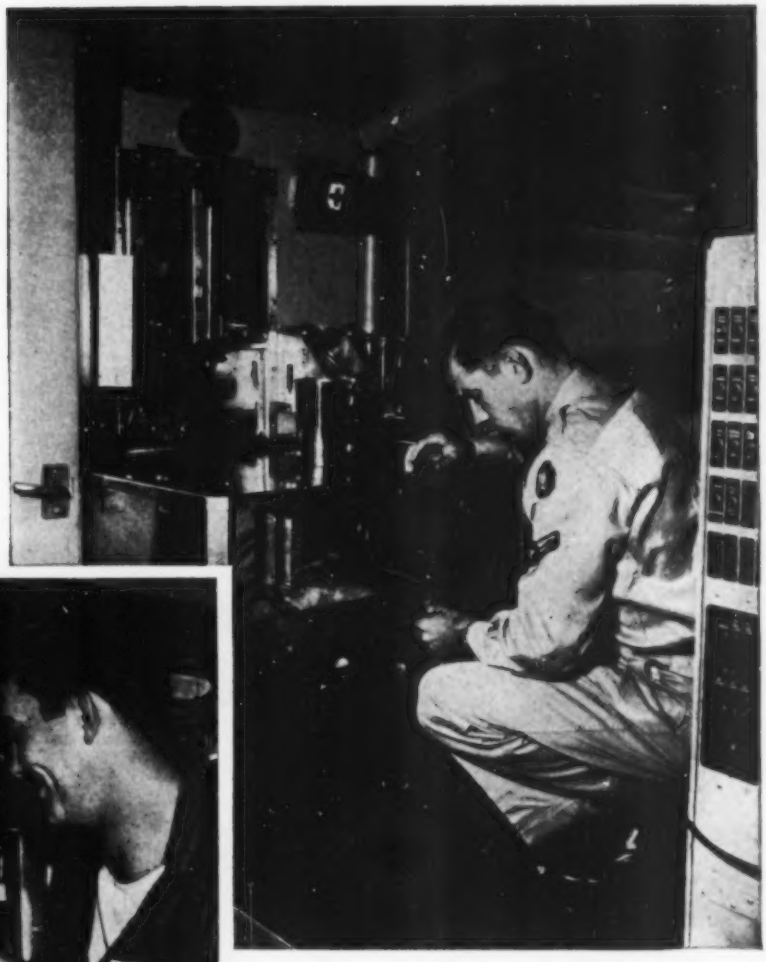

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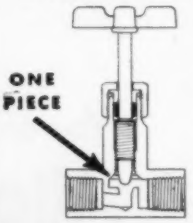

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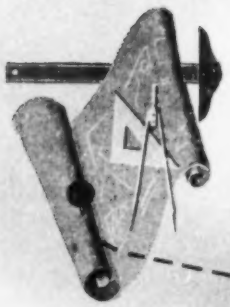

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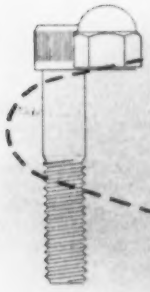

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THE MAN WE MEAN IS A COMPOSITE of the editorial staff of this magazine. For, obviously, no one individual could ever accomplish such a vast business news job. It's the result of many qualified men of diversified and specialized talents.

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Hydraulically balanced, high-pressure, high-volume pumps in a range of sizes for circuits of 3000 and 5000 psi capacity . . . volume capacities 3.5 to 35 gpm. Constant volume, or variable volume with control by hand wheel, pressure compensation, stem, or cylinder. Face, flange or foot mountings. Catalogs P-4-1, P-4-2, P-4-3, P-4-10.

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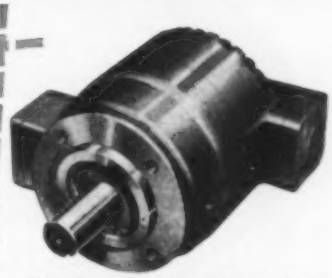

Vane-Type Single-Stage Pump/Motors,
built for continuous use at pressures to 2000 psi, are ready for either pump or fluid motor duty without alterations. Rotation of shaft can be either direction without internal adjustment. Four sizes, plus interchangeable cam rings, offer pumping capacities from 2½ to 70 gpm, or torque ratings from 13 to 257 inch-pounds per 100 psi. Catalog P-5.

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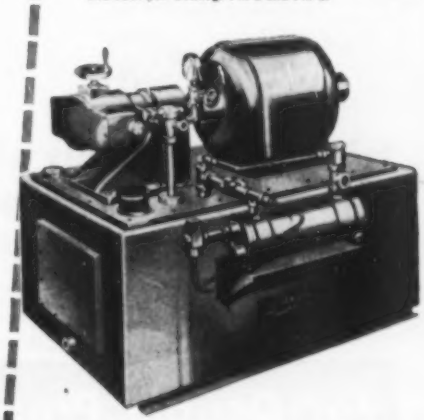
Four sizes, with torque capacities ranging from 510 to 5585 inch-pounds (about 24 to 160 HP). Speeds to 2000 and 3000 rpm. Compactly built . . . largest size is only about one foot in diameter. For circuits of 2500 and 5000 psi. Catalogs FM-2 and FM-3.



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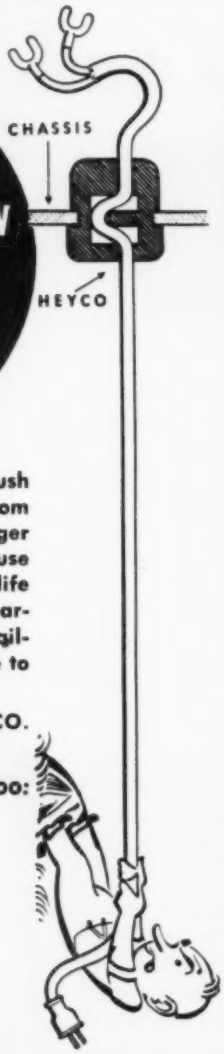

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1. *Slip over wire*
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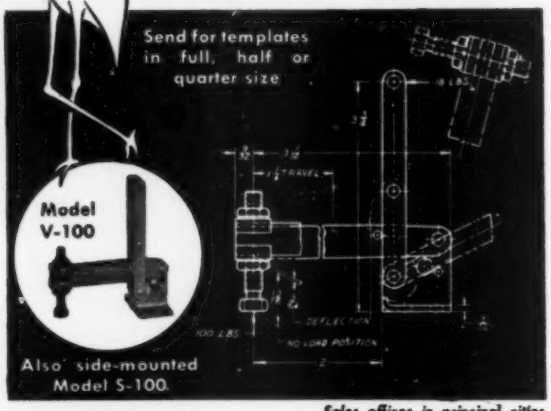

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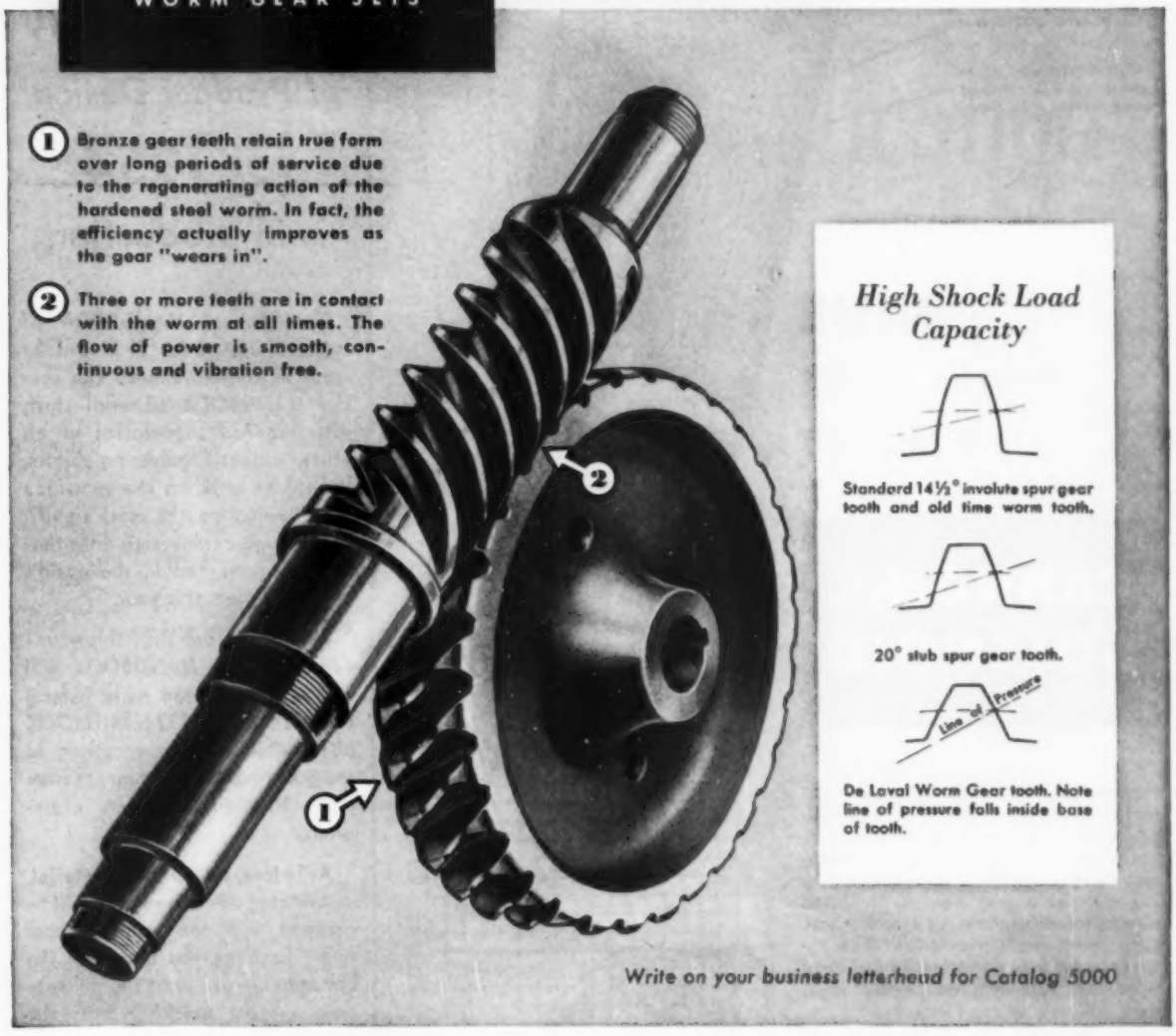
WORM GEAR SETS

can take "hard knocks"


1 Bronze gear teeth retain true form over long periods of service due to the regenerating action of the hardened steel worm. In fact, the efficiency actually improves as the gear "wears in".
2 Three or more teeth are in contact with the worm at all times. The flow of power is smooth, continuous and vibration free.
1
2
High Shock Load Capacity
Standard 14½° involute spur gear tooth and old time worm tooth.
20° stub spur gear tooth.
Line of Pressure
De Laval Worm Gear tooth. Note line of pressure falls inside base of tooth.
Write on your business letterhead for Catalog 5000

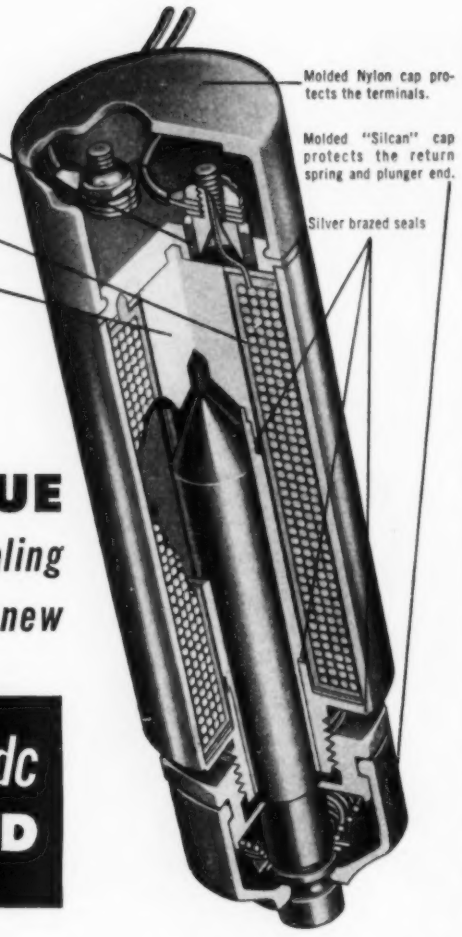
De Laval worm gear sets are designed to take punishment year-in, year-out. Gear teeth are under a crushing, instead of a bending load. Thus they withstand extremely high momentary and shock loads damaging to other forms of gearing. They need little attention even under the most rugged operating conditions.

De Laval manufactures these heavy-duty sets in a wide range of ratios from 3:1 to 100:1, with ratings of .1 hp to 550 hp and center distances from 3″ to 36″. It pays to design around these De Laval stock sizes. Special sets, however, can be furnished to any detailed specifications.

Proven applications of De Laval worm gear sets include the machine tool industry, rolling mills, process machinery, cranes and hoisting equipment and many similar uses.

DE LAVAL *Worm Gear Sets*

DE LAVAL STEAM TURBINE COMPANY
801 Nottingham Way, Trenton 2, New Jersey


Terminals are hermetically sealed by exclusive process developed for Cannon's widely acclaimed hermetically sealed electric connectors.
Insulation test: 1000v ac
The armature (plunger) and the anvil are high quality annealed Armco magnetic ingot iron.
Molded Nylon cap protects the terminals.
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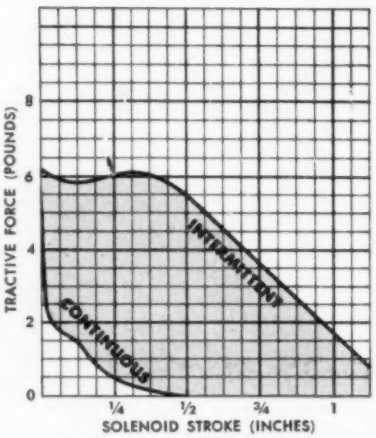
Silver brazed seals

TRUE
hermetic sealing
in this new

CANNON *dc* SOLENOID

For pressurized or corrosion resistant service, Cannon's dc Solenoids offer positive hermetic sealing, sound construction, painstaking workmanship and highest quality materials. A vitreous insulating material is heat-fused to shell and contact terminals, creating a perfect seal. Other parts are silver brazed. The entire solenoid is then copper-nickel-chrome plated to insure complete coverage, high corrosion resistance and long, trouble-free service. Solenoid No. 19760, above, the first hermetically sealed product of this type, is built for continuous duty on 28v dc systems. Fitted with other coils, it renders intermittent duty as characterized by the chart at right. Cannon's hermetically sealed solenoid series reflects the same uncompromising attention to details of sound design, engineering and workmanship that has made the name "Cannon" synonymous with "quality" for more than 38 years. For complete information write for new Solenoid Bulletin DCS4-1953 showing 105 different assemblies.



Solenoids of the hermetically sealed 19760 series, through modification of the coil windings, can meet various characteristics and specific applications within the limits indicated above.

CANNON ELECTRIC
Since 1915

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HANDBOOK
of Product Design
for 1954
is in production

The Annual HANDBOOK of Product Design for 1954 **will be ready in Mid-November. Our special *HANDBOOK* editorial staff, with the full cooperation of all other *Product Engineering* editors, is hard at work on the year-long job of selecting the most significant design-engineering data that is being published in the world's technical press this year.**

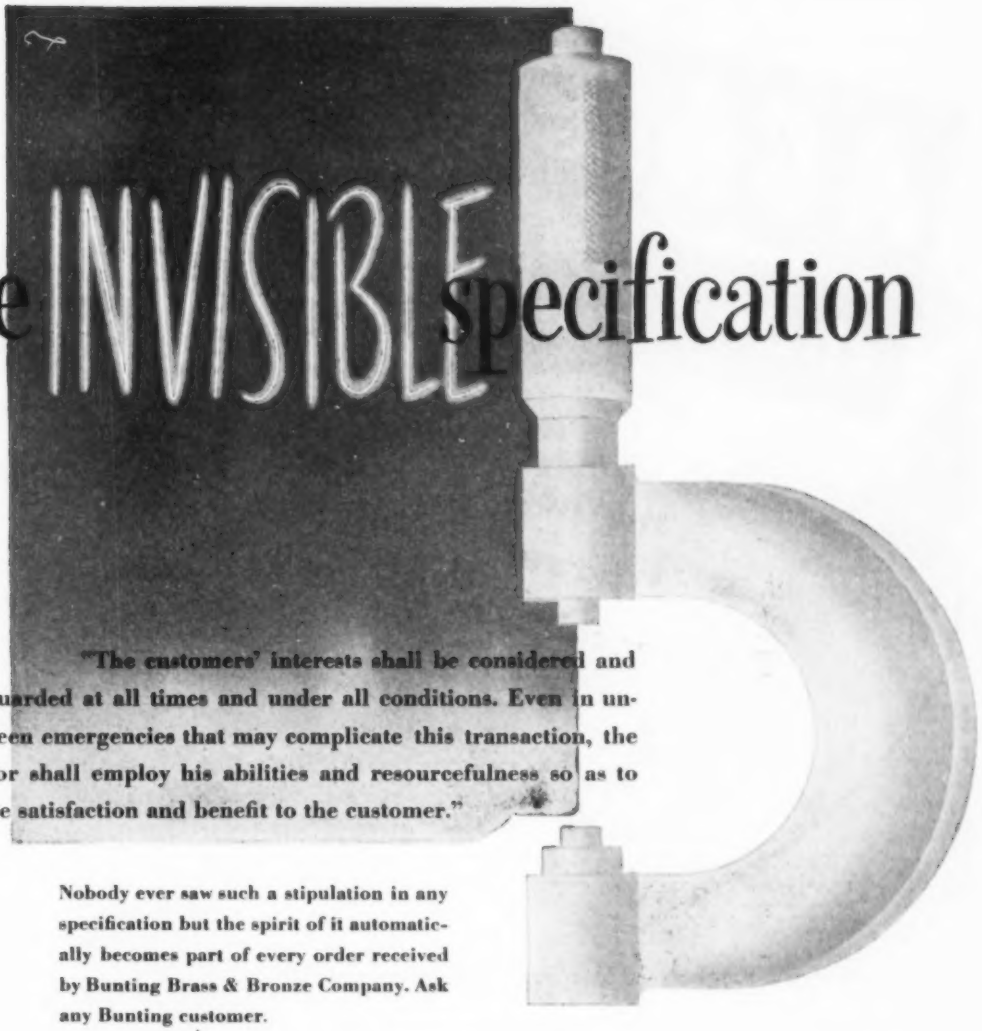
Indications are that this year's edition of the *HANDBOOK* will be even bigger and more helpful to you than the *1953 HANDBOOK* about which we are receiving so many enthusiastic comments from product-design engineers everywhere.

As before, all editorial material, and related advertisements, will be grouped into ten separate sections, enabling you to locate the information you want on any specific subject quickly. Both the editorial and advertising pages will be thoroughly indexed and, in addition, the 1954 edition will carry a complete editorial index of the *1953 HANDBOOK*.

Again this year, the *HANDBOOK* will come to you as part of your regular subscription to *Product Engineering*.

Product Engineering
330 West 42nd St.
New York 36, N. Y.

the INVISIBLE specification



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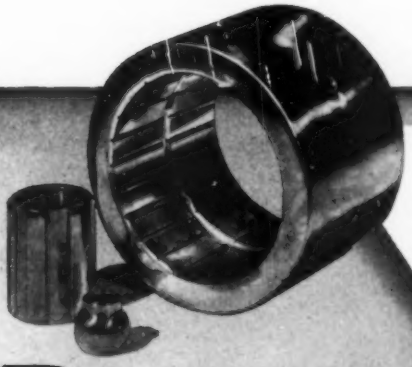
Nobody ever saw such a stipulation in any specification but the spirit of it automatically becomes part of every order received by Bunting Brass & Bronze Company. Ask any Bunting customer.



The sleeve bearing is not complex in structure; it conforms readily to design requirements; it is easily installed. Cast Bearing Bronze is the most adaptable of all sleeve bearing materials; it possesses excellent anti-friction properties. With proper film lubrication, its coefficient of friction is as low as can be obtained with any other bearing type. A successful Bunting Bronze bearing installation is readily attainable. We ask the opportunity to work with you, and to quote on your requirements.

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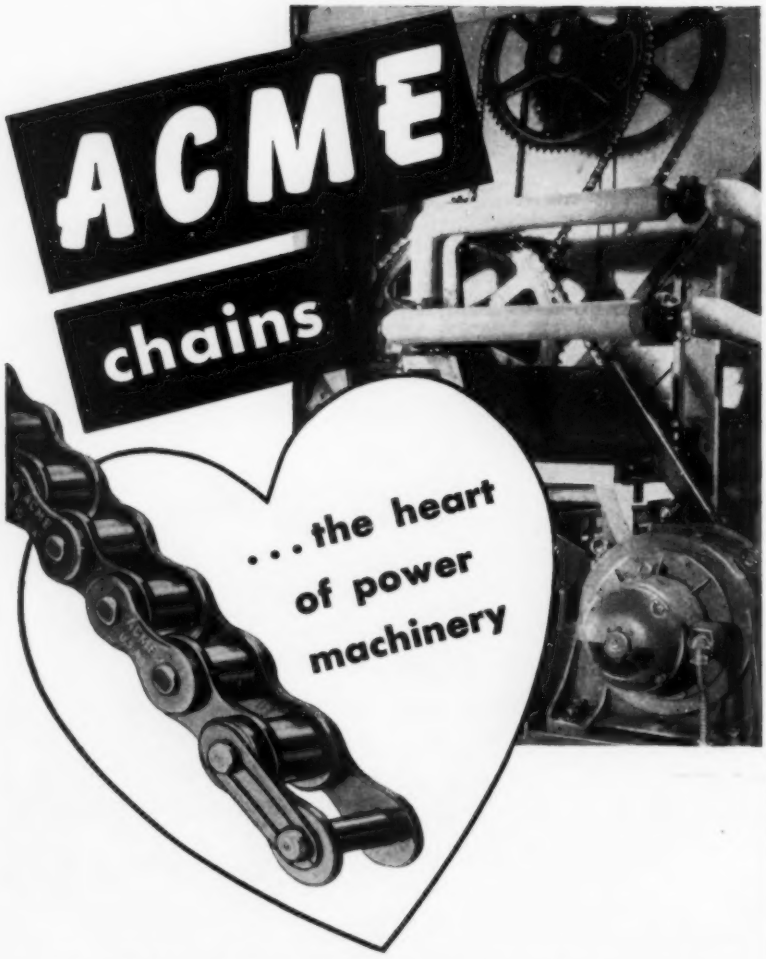

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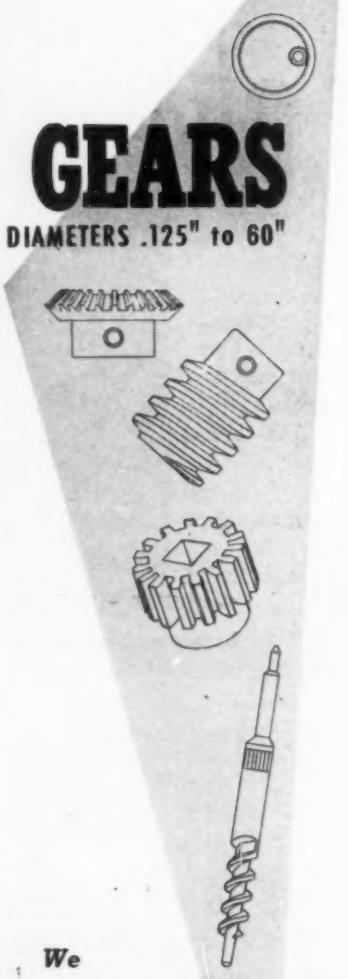

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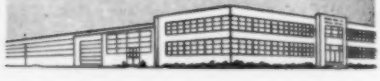

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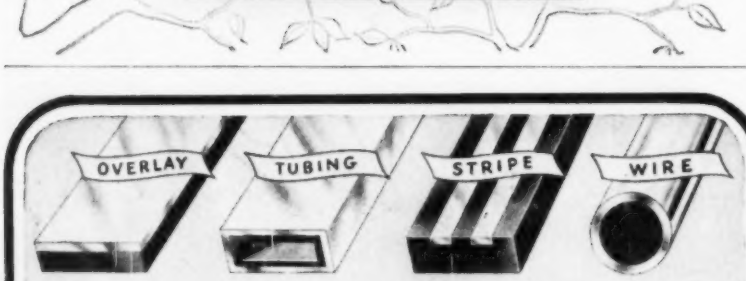

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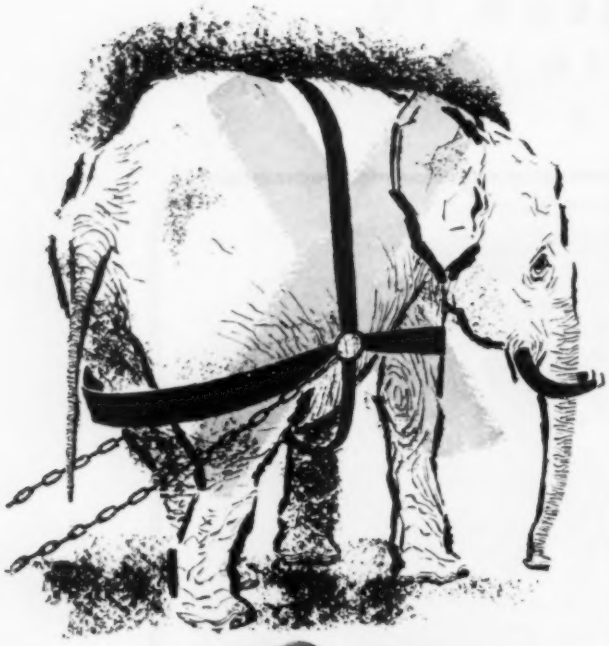

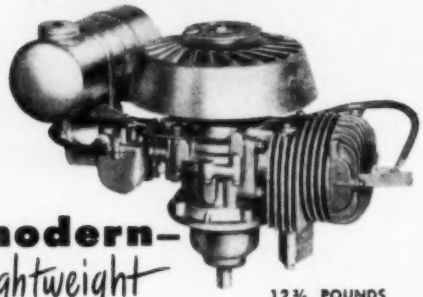

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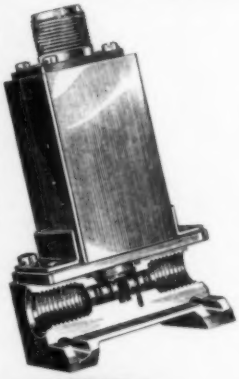

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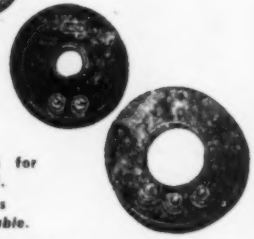

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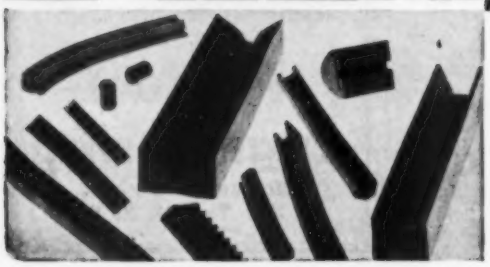

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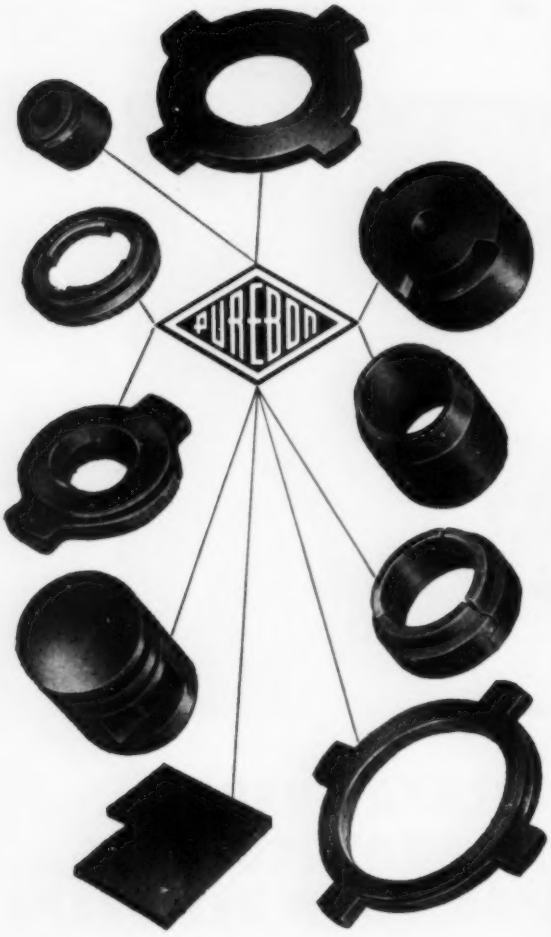

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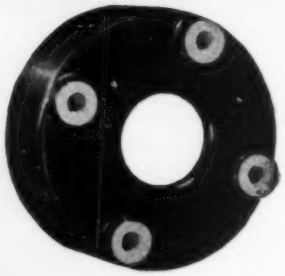

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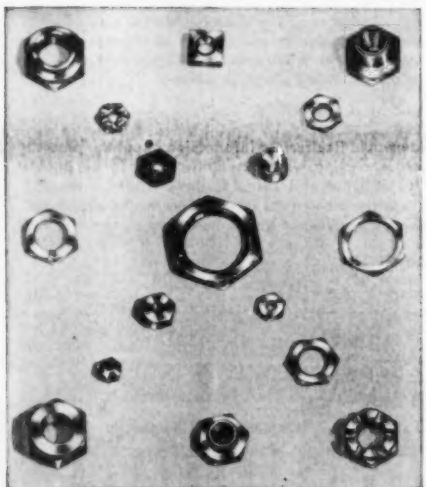

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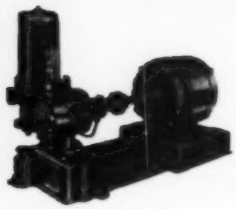

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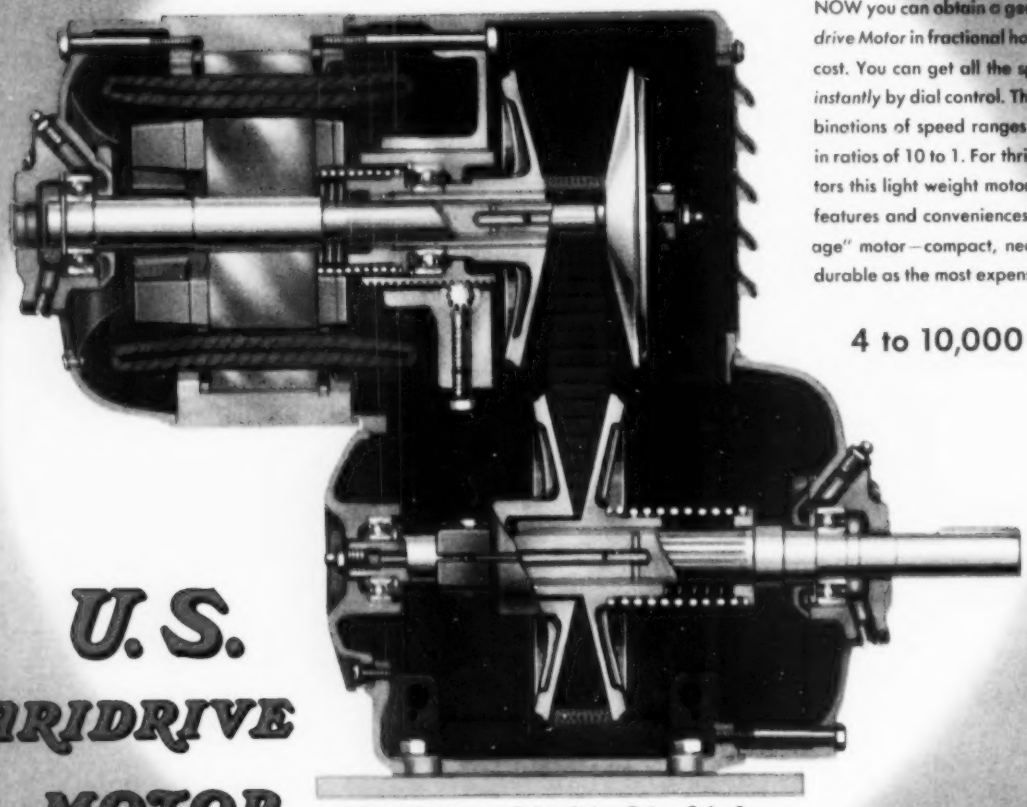

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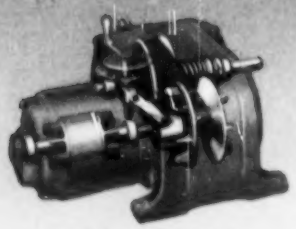
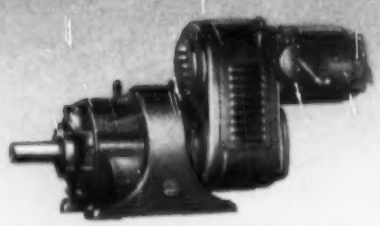


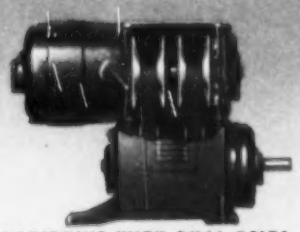
TYPE VE VARIDRIVE

Horizontal type. Take-off shaft can be positioned left or right. All Varidrives embody asbestos-protected windings, normalized castings, Lubri-flush bearings and centricast rotor.



TYPE VEV-GD WITH SYNCROGEAR

Combination type embodying Syncrogear, for extra low speeds and high torque. Varidrive unit is mounted on Syncrogear, upright as shown above, or can be set horizontally.



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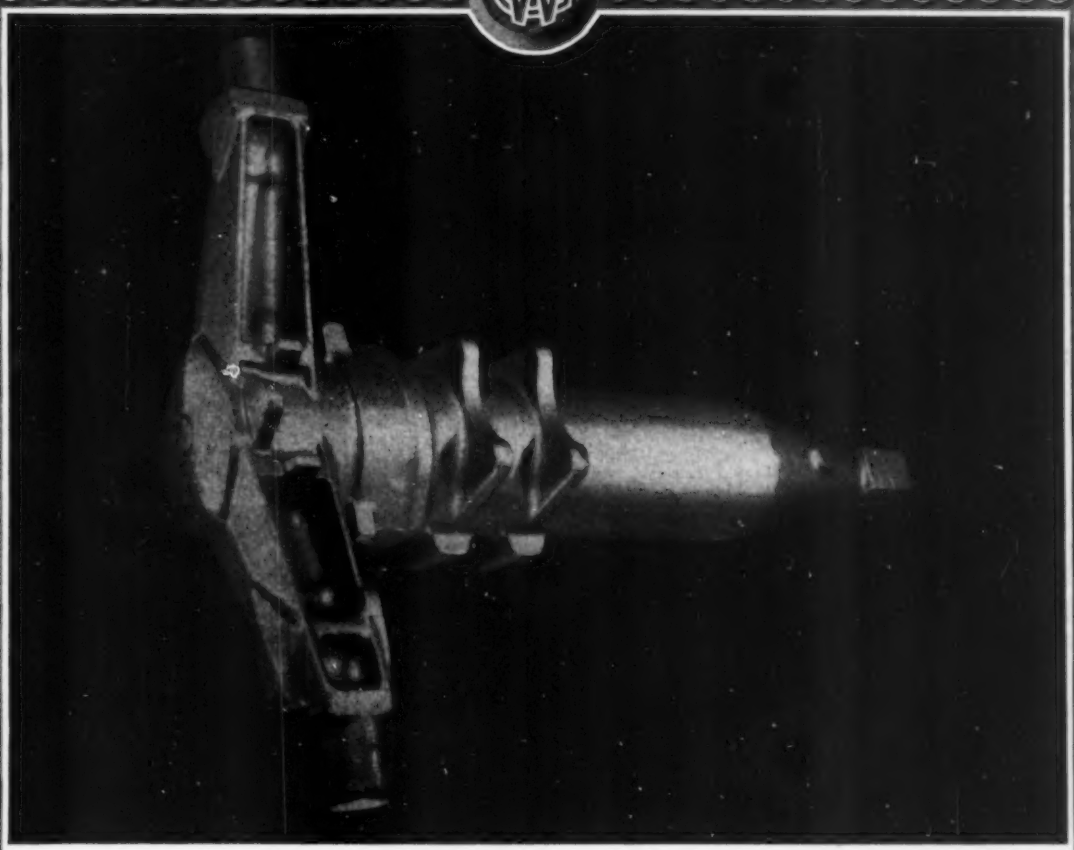

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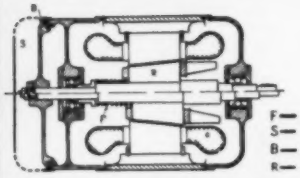
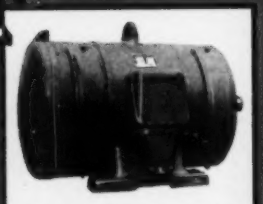


Upper half: motor with brake released. Lower portion: components when brake is applied. When power is applied, rotor in brake-applied-position unbalances magnetic field, setting up a horizontal force releasing brake.



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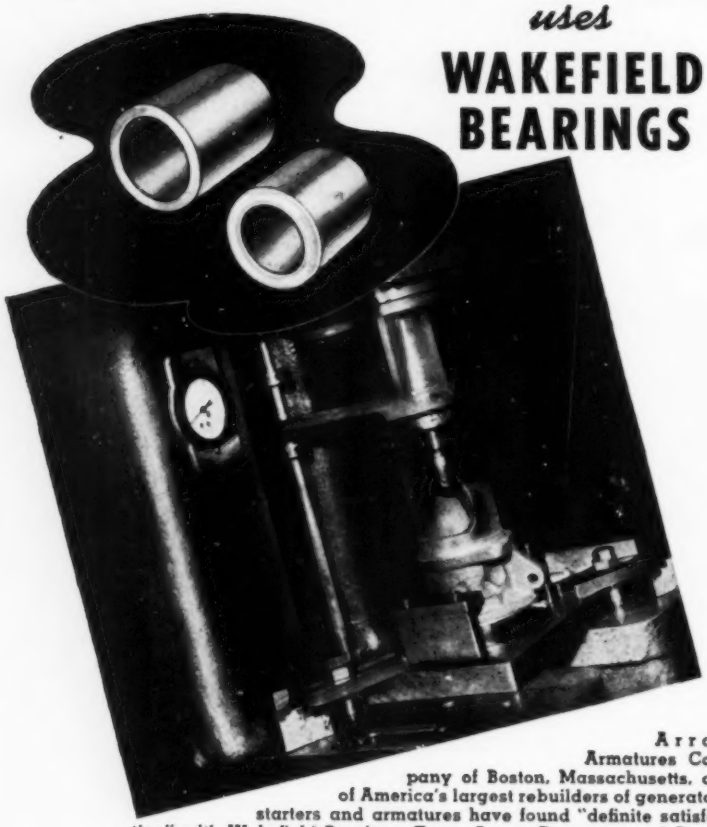

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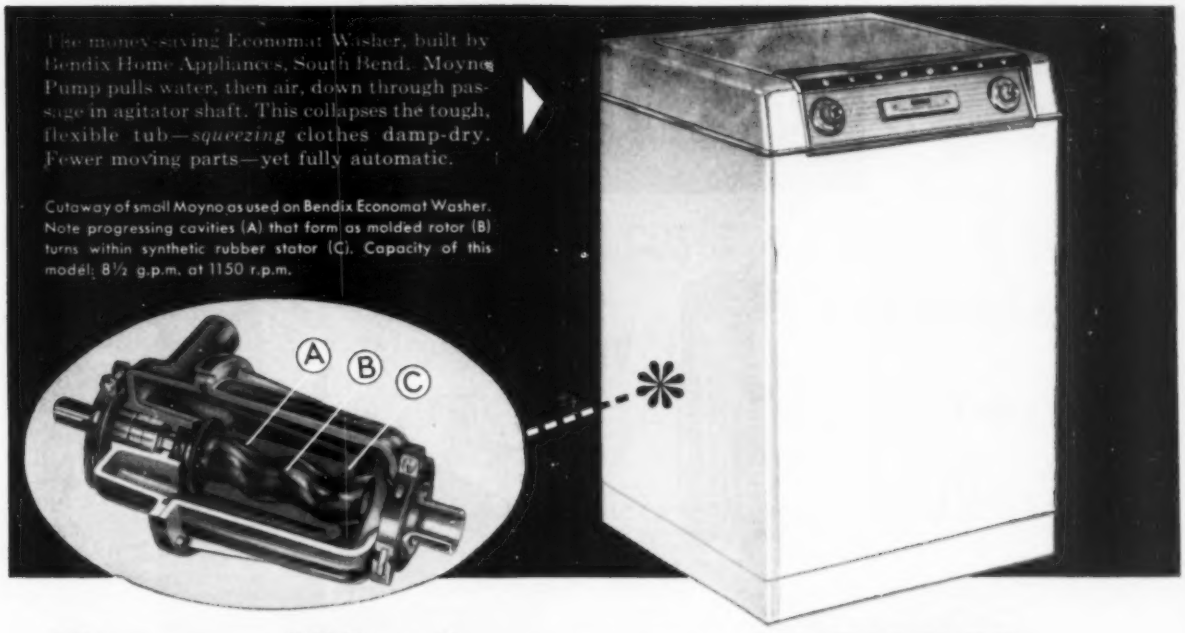
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A
B
C

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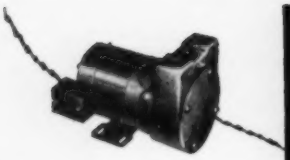

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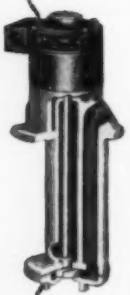

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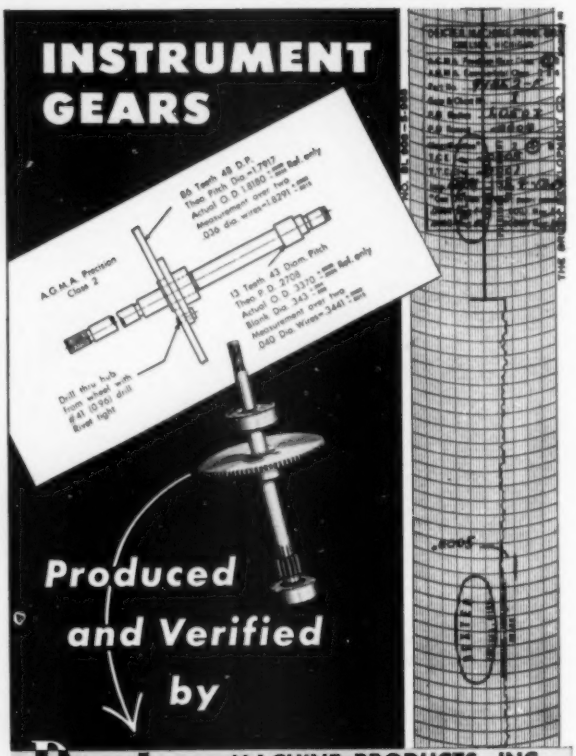

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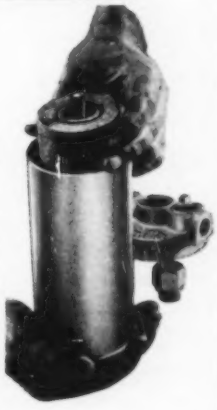

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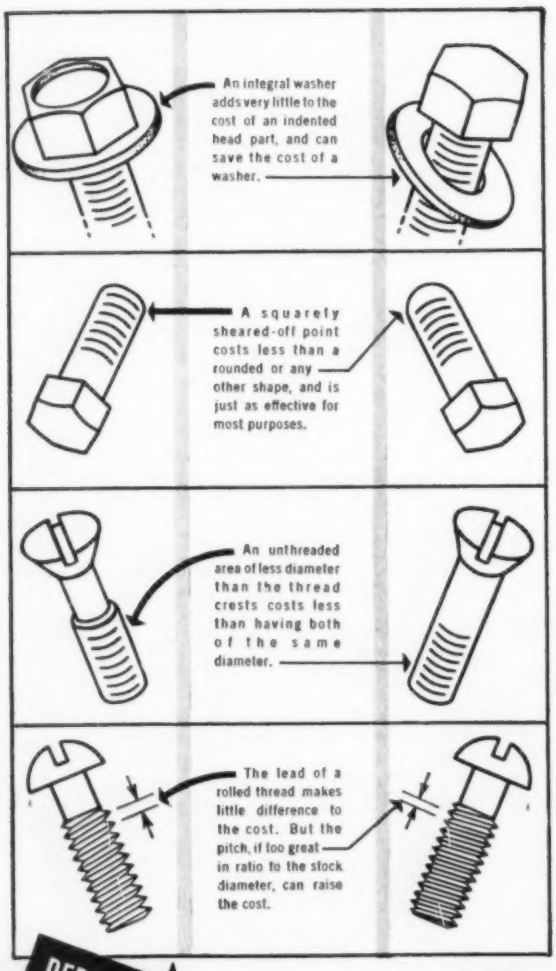
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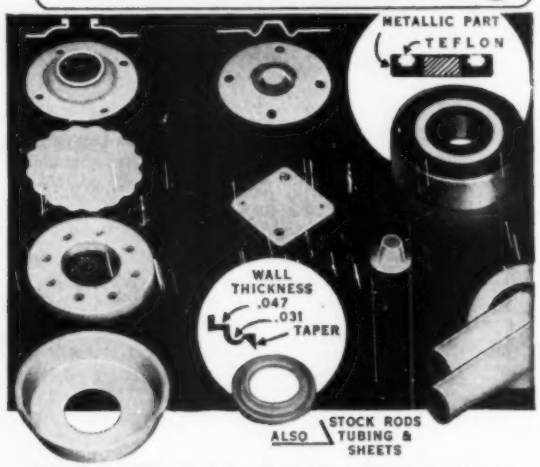

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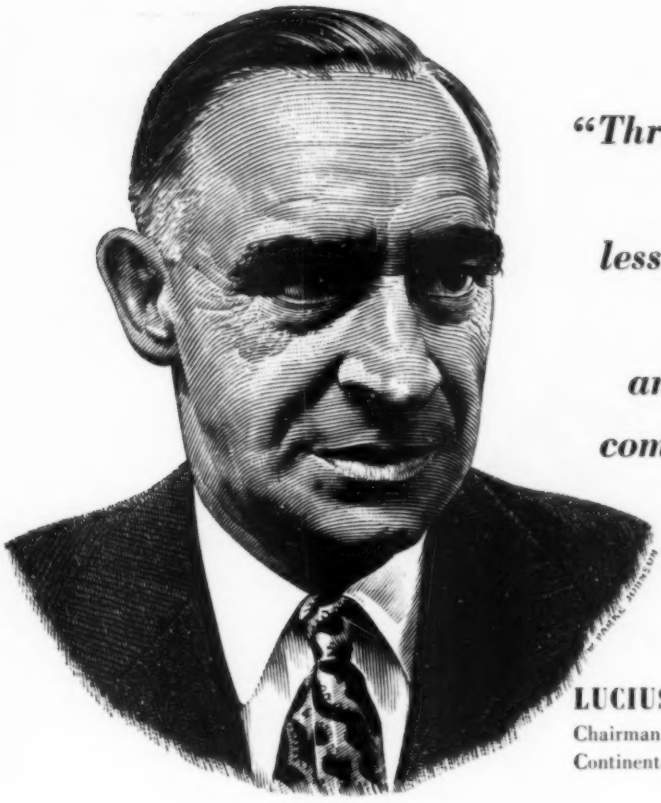

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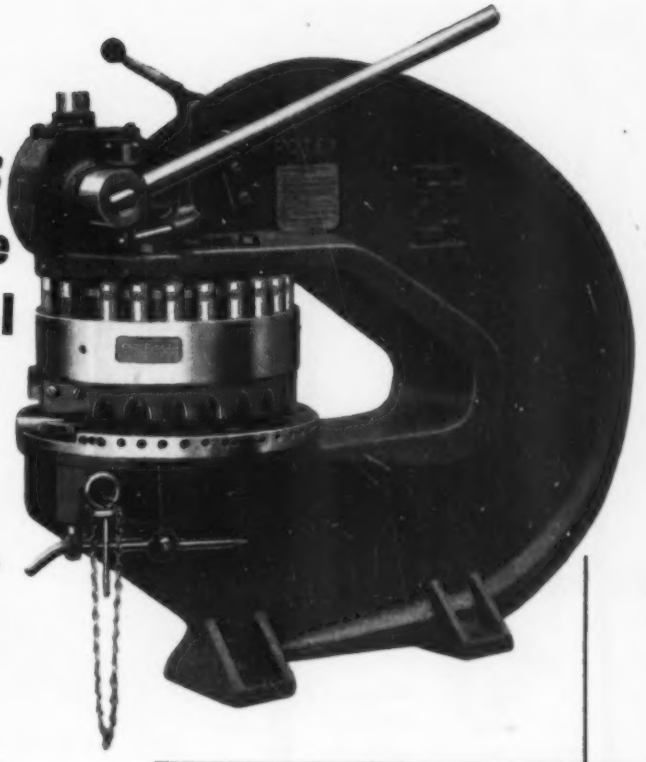

Speed Case (X1515) low carbon, open hearth, steel plate has won the favor of numerous manufacturers of machine tools, because of its machinability, its ease of finishing and response to the various case hardening methods.

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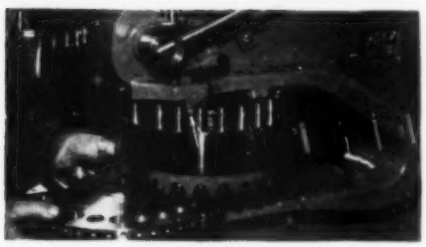

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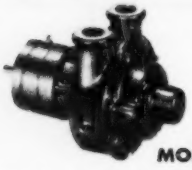

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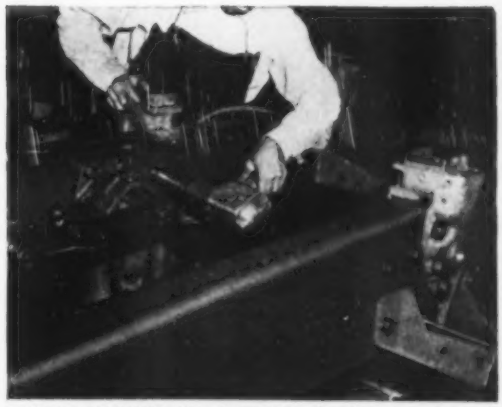

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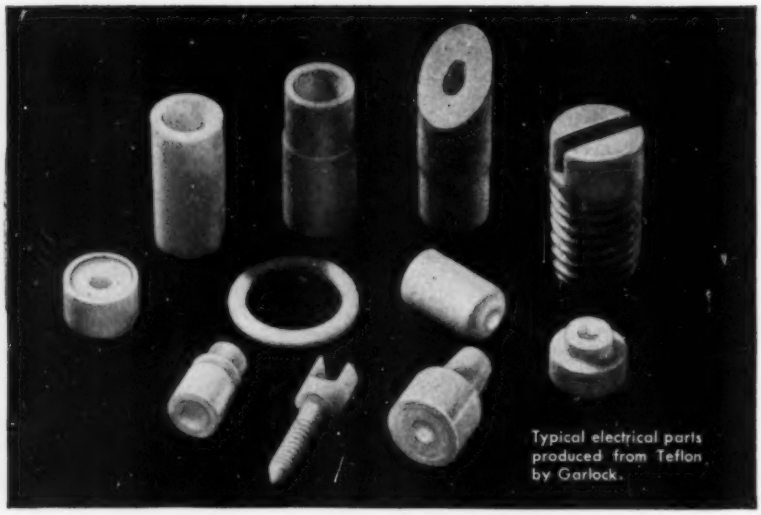

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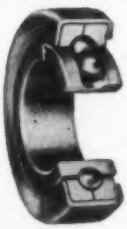

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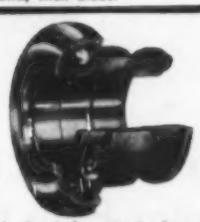

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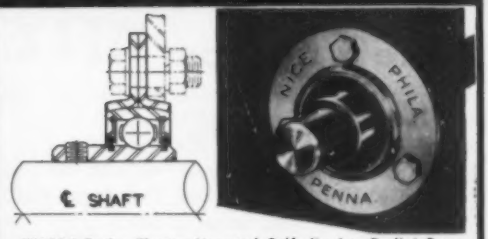

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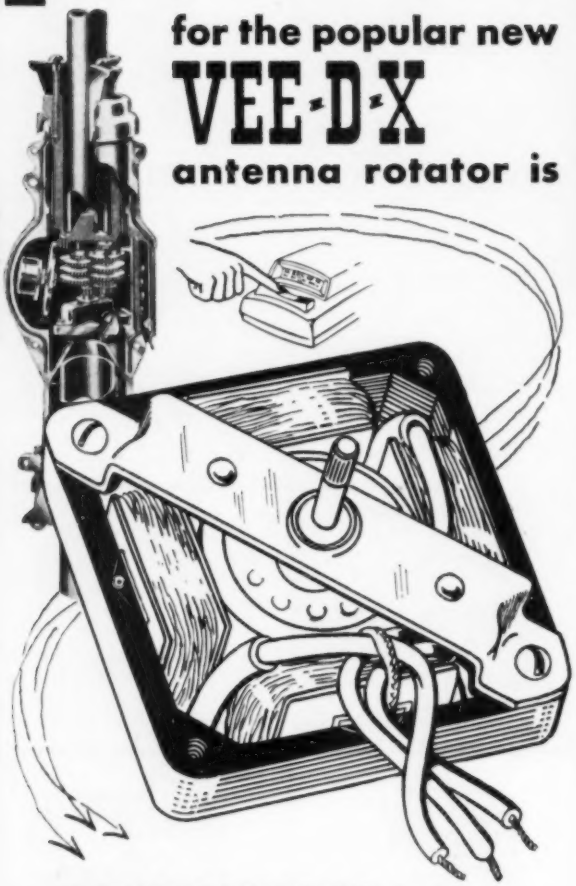

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"I could see the corpsman kneeling over me. The blood plasma was running down through a tube into my arm and he said everything was going to be O.K. I was walking across an enemy mine field in Seoul when one exploded and a piece of shrapnel caught me in the leg.

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Business Executives!
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- ☐ Have you informed employees of your company's plan of co-operation?
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National Blood Program

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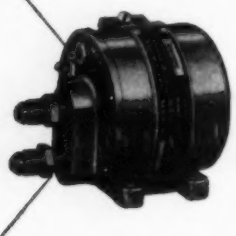

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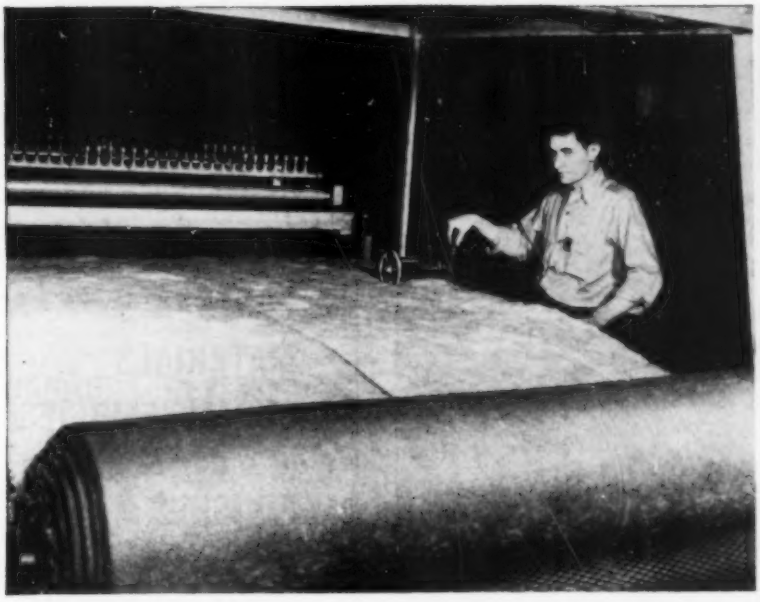

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Product design is no longer restricted by heavy, space-consuming features of old-type insulation.

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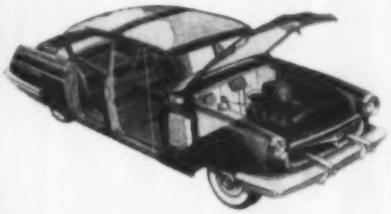

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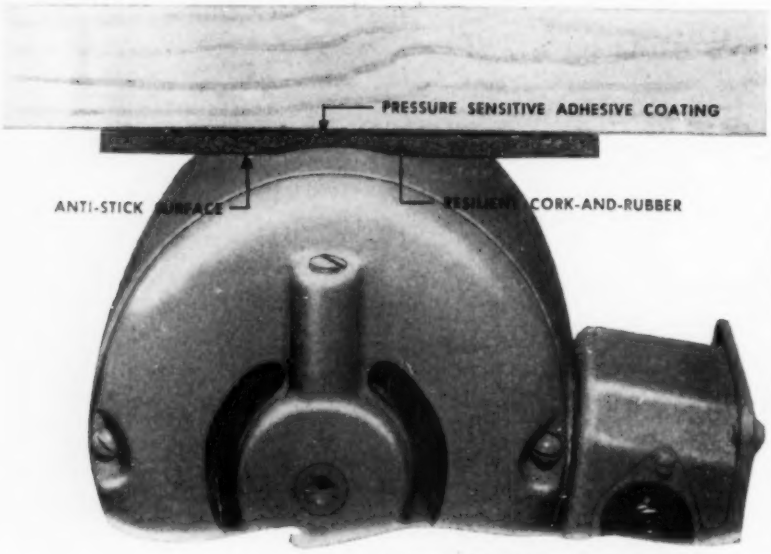

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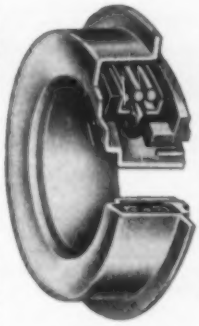
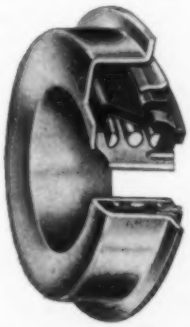


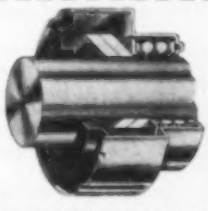
TYPE 6-A

Pressed-in packaged unit recommended for small shafts on hot or cold water, oil, gasoline or soapy liquids . . . pressures to 75 psi . . . temperatures from —65° F. to +220° F. Available in stainless steel or bronze.



TYPE 11-A

Pressed-in packaged unit with spring inside synthetic rubber bellows to protect against corrosion. For hot or cold water, oil, gasoline or soapy liquids . . . pressures to 35 psi . . . temperatures from —65° F. to +212° F.



TYPE 19

An all-purpose seal suitable for handling practically any liquid or gas, including highly corrosive acids and oils.

Low or high temperatures from —100° F. to +450° F. . . . pressures to 200 psi. Incorporates highly efficient sealing cones made of Du Pont's Teflon, which is inert to practically all chemicals.

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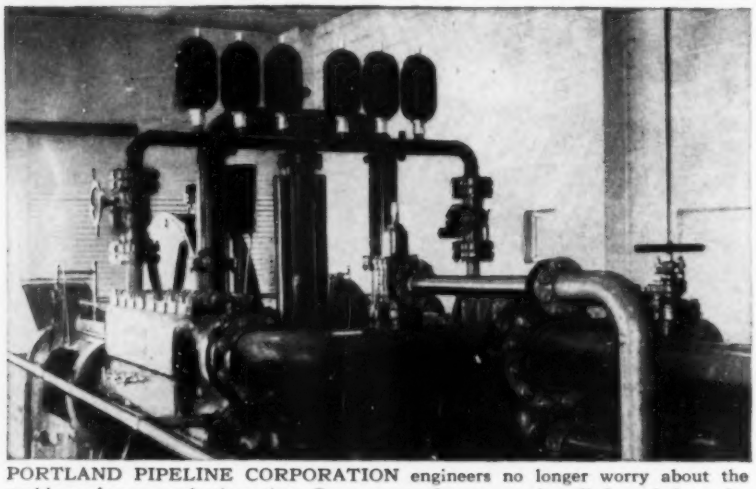
JOHN CRANE **CRANE PACKING COMPANY**

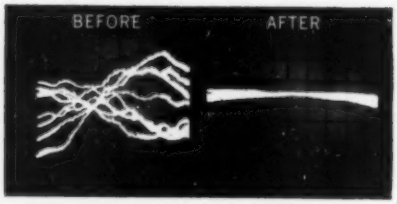
GREER TOPICS

Functions and Applications of the Greer Accumulator



PORTLAND PIPELINE CORPORATION engineers no longer worry about the problem of pump pulsations since Greer accumulators were installed on their equipment. Pressure surges from reciprocating pumps were rendered harmless. See below.

How Greer Accumulators Reduce Pump Pulsations



PROOF POSITIVE! Hydrauliscope photographs, taken before and after the installation of Greer accumulators, give conclusive evidence that pump pulsations were reduced more than 67% for Portland Pipeline pumping equipment. Write or call Greer now for special Bulletin 500 that gives complete technical data and diagrams on pump pulsation problems and corrections.

Actual hydrauliscope tests prove pressure surges can be reduced as much as 90%

The most common cause of pipeline and hydraulic system failure can be traced to the dangerous pulsations of reciprocating pumps. A positive remedy for this hazard is the versatile Greer Hydro-Pneumatic Accumulator.

This compact power package, with its unmatched ability to absorb shock, renders pump pulsations harmless. The result is a smooth, steady flow of fluid so vital to efficient hydraulic operation.

Are you troubled with a pump pulsation problem? Then let our experienced hydraulic engineers demonstrate how costly downtime can be avoided, how performance and production can be improved, how equipment can be given longer life with the installation of a Greer accumulator. Write or call today.

Greer Hydro-Pneumatic Accumulators have many other diversified functions

(1) Pressure storage chamber for main, auxiliary and emergency power (2) Pressure-volume compensator for leakage and temperature (3) Dispenser of fluids and lubricants (4) Transfer-barrier for fluids and gases (5) Shock absorber for line shock and pump pulsation.

Precision engineered to make any hydraulic system better! Complete data and diagrams in Brochure 301. Write for your free copy.

GREER ACCUMULATORS

U.S. PATENTS UNDER OLAER LICENSES

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Field Offices: 1908 West Cermak Road, Chicago, Illinois • 25 South Main Street, Dayton, Ohio 2832 East Grand Boulevard, Detroit, Michigan • and sales representatives in all principal cities

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Sealing Unlimited!

over 400 sealants to

Seal IN the quality of your product

Seal OUT dirt, water, rust, air...

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Sealers and adhesives to seal windows and seams against dust, air and water, to prevent rust and corrosion in seams, to seal spot welded body joints in cars, trucks and trailers.

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Sealers for fuselage seams, fuel tanks, and pressurized cabins. Sealers for windshields, windows and gun turrets.

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Many sealing compounds such as Permagum, Mastics, Thermal Mastics and Elastic Compounds are used in refrigerators, freezers and air conditioning equipment.

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Sealers for joining sewer pipes, sealing expansion joints in concrete highways and airport runways, waterproofing underground concrete, protective coatings and caulking compounds, barrier paper.

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Sealers and adhesive felt tapes for insulating, soundproofing and weatherproofing of railway cars, sealing car windows and observation domes, and sealers for spot welded seams.

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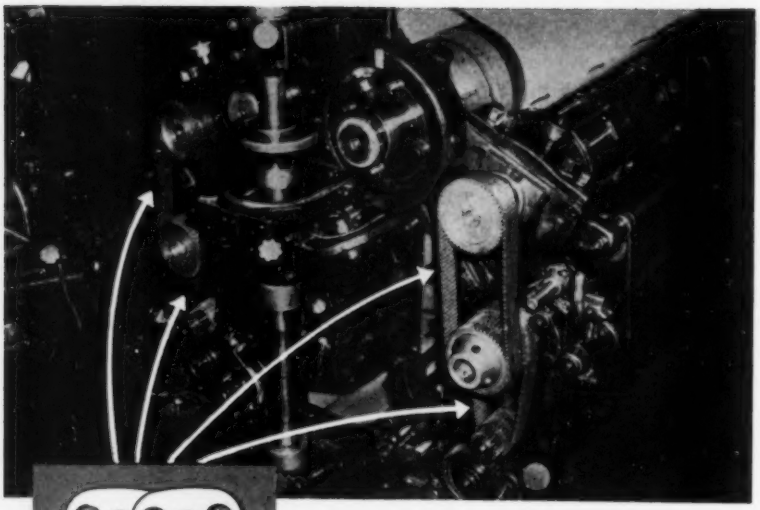
PRESSTITE ENGINEERING COMPANY

3750 Chouteau Avenue St. Louis 10, Missouri



• THE UNIQUE, FRICTIONLESS RAMSEY JOINT enables the chain to flow over the sprocket as smoothly as water flows over a dam. Note in the picture above how the contact surfaces of the pins roll on each other. Ramsey Chains take no toll of the power they transmit.

For increased production, quietness, efficiency

RAMSEY SILENT CHAIN DRIVE

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FREE APPLICATION MANUAL FOR ENGINEERS

This 60 page book gives you the range and scope of Ramsey Silent Chain Drives—tells you how to work out applications and includes the necessary data on chains, sprockets and pinions. Write for a copy today.

SILENT CHAIN DRIVES – FLEXIBLE COUPLINGS

RAMSEY
CHAIN COMPANY, INC.
5150 BROADWAY • ALBANY, N. Y.

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"THAT TAYLOR-WINFIELD OUTFIT CAN GIVE US SOME REAL HELP"
"THEIR FIELD MEN WILL SERVICE THE EQUIPMENT"
"THEY WILL ENGINEER THE WELDERS INTO OUR PRODUCTION SET-UP"
"THEIR APPLICATION ENGINEERS WILL SHOW US THE BEST WAY TO RESISTANCE WELD THESE PARTS"
"THEY'VE ALWAYS BEEN KNOWN AS THE QUALITY COMPANY IN RESISTANCE WELDING"

IF YOU HAVE a production joining problem, bank on resistance welding and use the facilities of Taylor-Winfield. We have sales and application engineers who spend their time on specific customer projects.

If you will outline your needs, we will give you some practical help. T-W specializes in shirt-sleeve assistance on resistance welding. We design, engineer and build resistance welders into your production line. For prompt attention, address your inquiry to the nearest sales office.

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RESISTANCE WELDERS

Resistance Welders Since 1898

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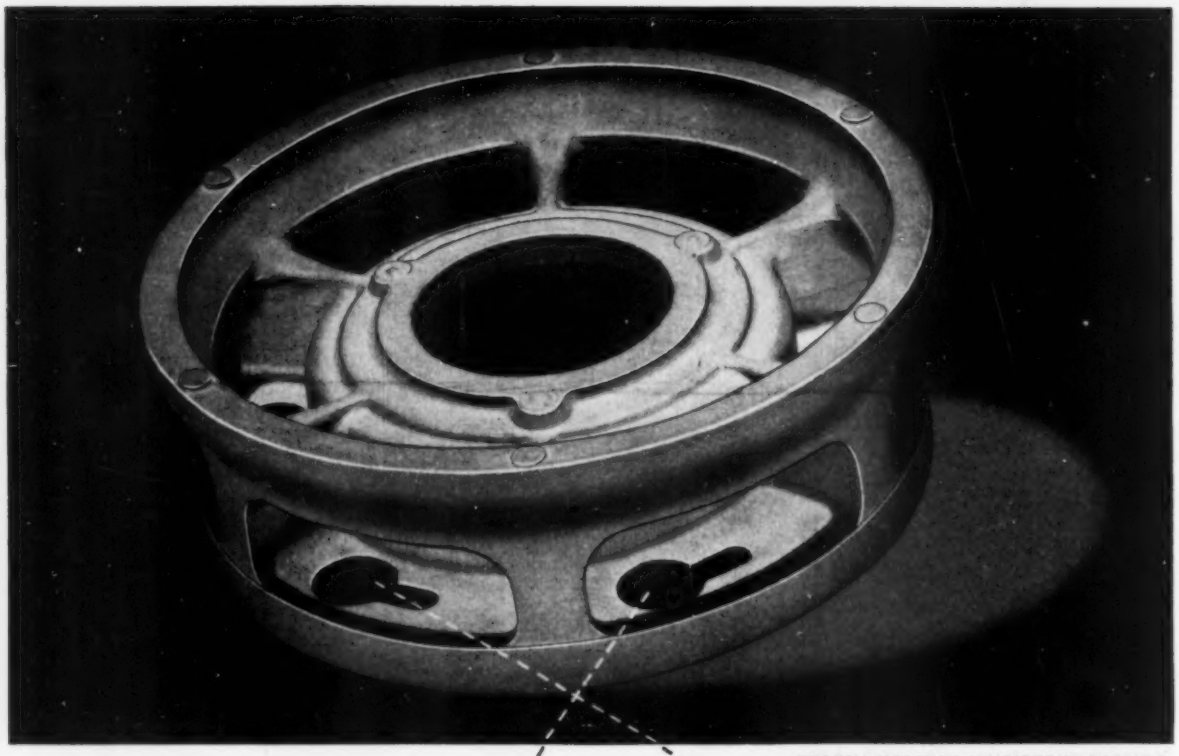

*FROZEN MERCURY INVESTMENT CASTING

MERCAST* Buttonholes

BUTTON A GENERATOR on or off of an airplane? Westinghouse does! And at a reported time saving of up to 8 man-hours per plane!

The ingenious new Westinghouse generator mounting bracket employs "buttonholes" that permit the assembly to be quickly slipped on or off over headed studs on the airframe. For practical production of this unit, a one-piece precision casting to close dimensional and surface tolerances is the economical answer. This casting, however, is much larger than can be produced by ordinary investment casting processes.

Westinghouse brought the problem to Alloy Precision Castings Company. Engineers and metallurgists at Alloy developed the illustrated 6 lb., 6½ inch diameter mercasting in 410 stainless. Critical tolerances are held to ±.003"/inch. Very little finish machining is required and the "buttonholes" are used as cast. Complete inspection by Alloy assures customers top quality and accuracy.

Mercasting made the Westinghouse generator mount idea a reality. Send details about your "impossible" or "too costly" jobs today! Learn how Alloy Precision can save you time and money with designs for mercasting.

A-6298

ALLOY PRECISION CASTINGS COMPANY, DEPT. C-2
45th and Hamilton, Cleveland 14, Ohio

Please RUSH Bulletin 706 describing the Mercasting Process.

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COMPANY _____

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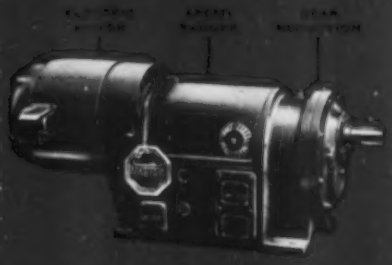
CITY _____

ZONE _____ STATE _____

ALLOY PRECISION *Castings Company*

EAST 45th ST. AND HAMILTON AVE. • CLEVELAND 14, OHIO



Don't put up with make-shift assemblies when it is so easy to get the RIGHT horsepower, the RIGHT shaft speed, the RIGHT construction features, the RIGHT mounting . . . all combined into one compact power package.

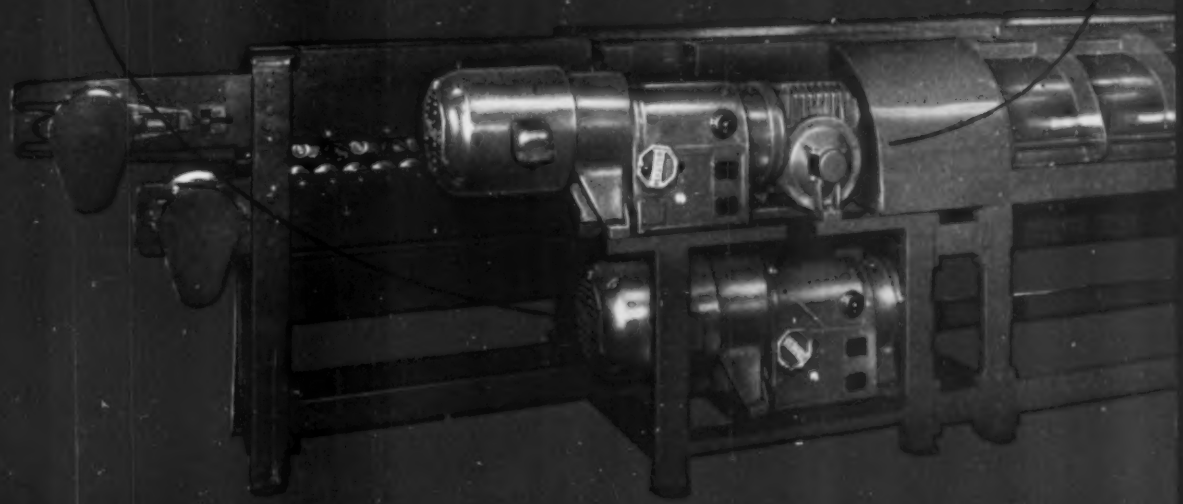
Master Motors are available in thousands on thousands of types and ratings (up to 400 HP) giving you a selection you can get nowhere else. This permits you to choose a power drive for each job that's just right . . . a power drive that will add greatly to the compactness, appearance, safety, and economy of each of your motor applications.

See how the designer of this tobacco processing machine has used two different Master units that are just right for his purpose . . . one, a motor with a variable speed unit and a right angle worm gear, the other a motor with a variable speed unit and a parallel shaft gear reduction unit.

you can always be right

Select the RIGHT power drive from Master's broad line and you can increase the saleability of your motor-driven products . . . improve the economy and productivity of your plant equipment. That's the horsesense way to use horsepower.

THE MASTER ELECTRIC COMPANY • DAYTON, OHIO



Makes delicate cuts on short, thin-wall, large diameter parts automatically

with help of TIMKEN® bearings

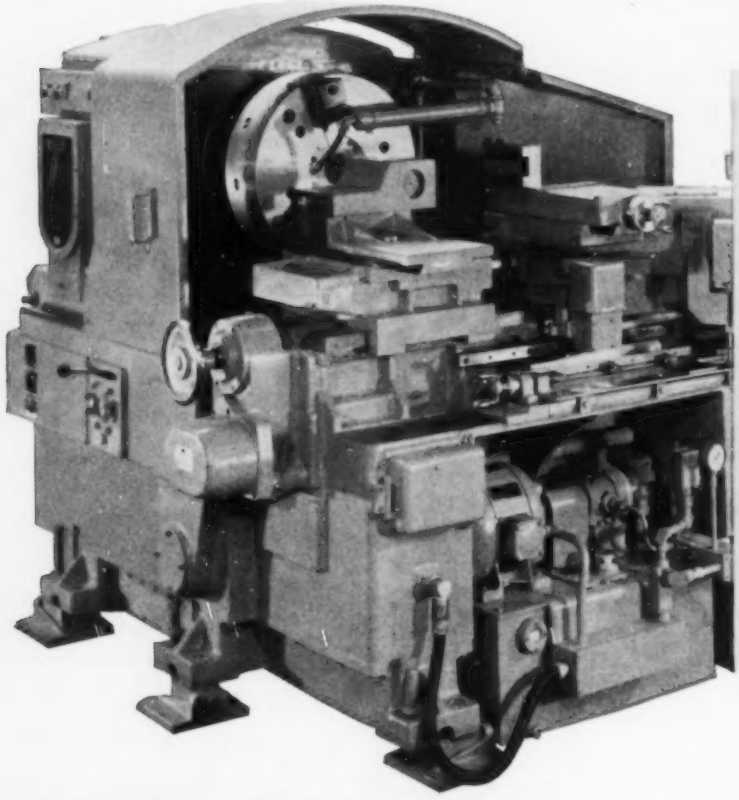
SPEED, precision and automatic operation—these are the machining qualities built into Lodge & Shipley's new 30″ T-Matic. With the bed at right angles to the spindle, it face contours, bores, turns big parts with small-lathe accuracy.

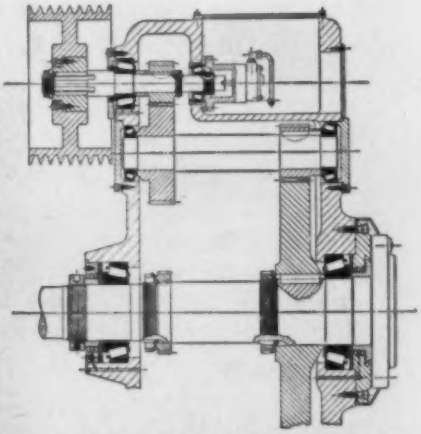
Since all the T-Lathe's work is single chucked, the spindle must be completely free of end play. Otherwise face contouring accuracy would be affected. Any wobble or chatter in the spindle would be doubled or tripled near the outside of large diameter parts.

For these reasons, Lodge & Shipley mounted the spindle on 2 Timken® bearings. Their tapered rollers are preloaded during assembly, eliminating both end and side play. Since the spindle must support large work pieces, these are large diameter bearings. Yet their run-out never exceeds three ten-thousandths of an inch (.0003″).

Made of the Timken Company's own fine alloy steel, Timken bearings normally last the life of the machine tool they're a part of. Building or buying machines, specify "Timken". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

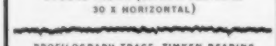
This symbol on a product means its bearings are the best.





How **THE LODGE & SHIPLEY COMPANY** mounts T-Lathe spindle on Timken bearings to get accuracy needed for delicate work on large diameter pieces.

PROFILOGRAPH TRACE, GOOD COMMERCIALLY GROUND FINISH (5,000 X VERTICAL, 30 X HORIZONTAL)



PROFILOGRAPH TRACE, TIMKEN BEARING FINISH (5,000 X VERTICAL, 30 X HORIZONTAL)

OPTICAL FLAT, PERFECT FINISH

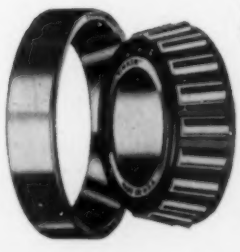
SMOOTH TO MILLIONTHS OF AN INCH

Surface finish of high quality Timken bearing rollers and races is so smooth that it takes a profilograph to measure its smoothness. This instrument measures surface variations to a millionth of an inch, as shown at the left.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS



NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ▯ AND THRUST →▯← LOADS OR ANY COMBINATION →✳←